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PROJECT EXPERIENCE REPORT

Demolition of Hanford's 233-S Plutonium Concentration Facility

Prepared for the U S Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U S Department of Energy under Contract DE AC06 96RL13200

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EXECUTIVE SUMMARY

This report provides a summary of the preparation, operations, innovative work practices, and lessons learned associated with demolition of the 233-S Plutonium Concentration Facility. This project represented the first open-air demolition of a highly-contaminated plutonium facility at the Hanford Site. This project may also represent the first plutonium facility in the U.S. Department of Energy (DOE) complex to have been demolished without first decontaminating surfaces to near "free release" standards.

Demolition of plutonium contaminated structures, if not properly managed, can subject cleanup personnel and the environment to significant risk. However, with proper sequencing and innovative use of commercially available equipment, materials, and services, this project demonstrated that a plutonium processing facility can be demolished while avoiding the need to perform extensive decontamination or to construct large enclosures. This project utilized an excavator with concrete shears, diamond circular saws, water misting and fogging equipment, commercially available fixatives and dust suppressants, conventional mobile crane and rigging services, and near real-time modeling of meteorological and radiological conditions. Following a significant amount of preparation, actual demolition of the 233-S Facility began in October 2003 and was completed in late April 2004.

The knowledge and experience gained on this project are important to the Hanford Site as additional plutonium processing facilities are scheduled for demolition in the near future. Other sites throughout the DOE Complex may also be faced with similar challenges.

Numerous innovations and effective work practices were implemented on this project. Accordingly, a series of "Lessons Learned and Innovative Practices Fact Sheets" were developed and are included as an appendix to this report. This collection of fact sheets is not intended to capture every innovative work practice and lesson learned, but rather to describe those that the project believes to be of most benefit to future DOE projects. These fact sheets cover a number of specific topics within the subject areas noted below:

- Project Management
- Organization Structure and Responsibilities
- Demolition Approach and Equipment
- Planning and Scheduling
- Site Preparation and Infrastructure
- Radiological Controls
- Industrial Safety and Health
- Waste Management.

INTRODUCTION

Hanford's 233-S Plutonium Concentration Facility had been in a slow and continual state of deterioration since its deactivation in 1967. For nearly three decades, surveillance and maintenance was performed to ensure confinement of the building's significant levels of plutonium contamination. Severe winter conditions in 1996 accelerated the rate of building deterioration and heightened the potential of personnel exposure to contamination and environmental release. Based on the increase in risks and associated facility maintenance costs, decisions (under processes of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [CERCLA]) were subsequently made by the DOE and the U.S. Environmental Protection Agency (EPA) to remove/demolish the facility (DOE 1997b).

The purpose of the 233-S Facility Demolition Project was to safely demolish the 233-S Facility and to package and properly dispose of all associated waste material. The scope of this project included the 233-S Plutonium Concentration Building (233-S Building), the 233-SA Exhaust Filter Building (233-SA Building), and the Mobile Office-317 (MO-317). A photo and schematic of the 233-S Facility are provided in Figures 1 and 2, respectively. Upon project completion, the concrete floor slabs for the 233-S and 233-SA Buildings remained in-place and were capped with concrete, then covered with clean fill, and posted as an underground radioactive material area.

The bulk of the building's materials were designated as low-level waste (LLW) and disposed in Hanford's CERCLA landfill known as the Environmental Remediation Disposal Facility (ERDF). Less than one percent of the demolition debris was designated as transuranic (TRU) waste; this waste was packaged for temporary storage at Hanford's Central Waste Complex, and will eventually be shipped for ultimate storage/disposal at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico.

Facility Description

The 233-S Facility was located in the southwest quadrant of Hanford's 200 West Area. Original construction of the facility began in 1953 and was completed in 1955. Several modifications (expansions) were made to the original structure over the following decade, resulting in an overall footprint of approximately 325 square meters (m^2) [3,500 square feet (sq ft)].

The 233-S Facility was comprised of the 233-S Building and the 233-SA Building. The 233-S Building was a reinforced concrete structure, with a footprint of 11.3 m (37 ft) x 25.7 m (86 ft), and roof elevations ranging from 3.7 m (12 ft) to 9.7 m (32 ft). Concrete wall thicknesses ranged from 23 centimeters (cm) [8 inches (in.)] to 30 cm (12 in.). Several exterior portions of the building were made of structural steel framing enclosed with corrugated metal exterior siding. The four-story portion of the 233-S Building (i.e., the process hood) was the area of highest contamination. The 233-SA Building, located northeast and just adjacent to the 233-S Building, was a single-story, reinforced-concrete structure with 15-cm (6-in.)-thick walls.

Figure 1. 233-S Facility (photo, looking south, taken before demolition began in October 2003). The 202-S REDOX facility is the large canyon building in background.

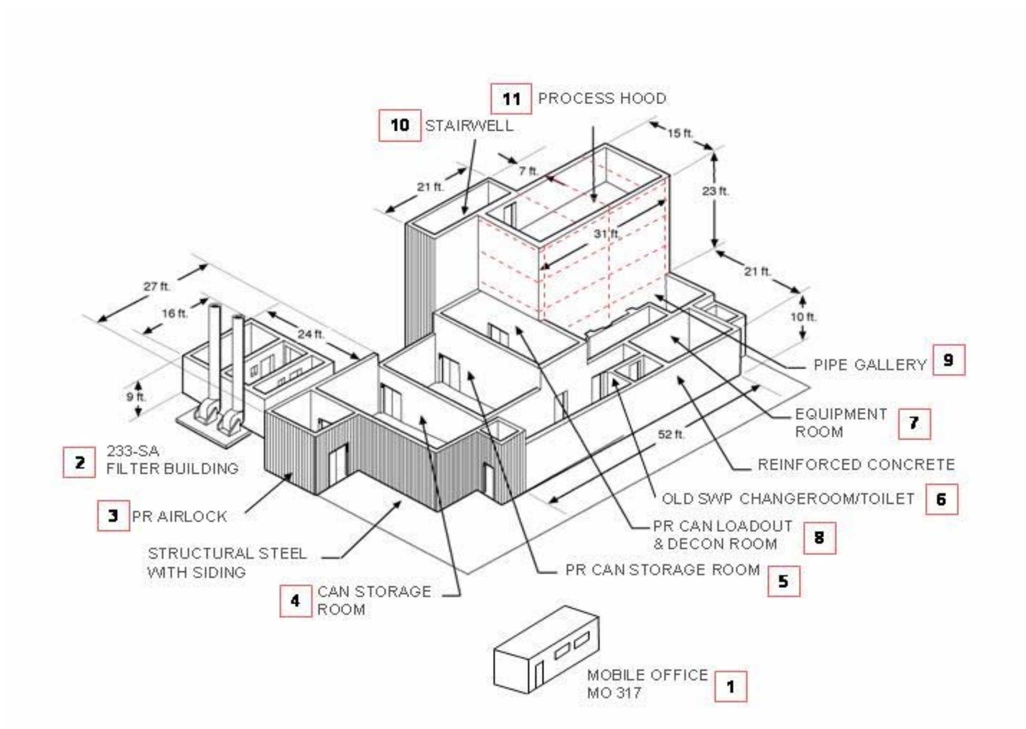

Figure 2. Schematic of the 233-S Facility (view looking to southeast; numbers in boxes indicate demolition sequence)

233-S Facility History

From 1956 to 1965, the 233-S Facility served a role in the process of developing weapons-grade plutonium. Hanford's plutonium production process began by irradiating uranium fuel at the Site's 100 Area production reactors. Spent reactor fuel was then transported to the 202-S Reduction and Oxidation Plant (REDOX) where the aluminum cladding was stripped from the fuel elements and plutonium was extracted as a plutonium nitrate solution. This solution was piped from the neighboring REDOX Plant to the 233-S Facility for additional concentration and packaging. Concentration was performed in the 233-S Building's process cell by evaporation and/or ion-exchange treatment. The concentrated plutonium solutions were then packaged in stainless steel, criticality-safe, product receiver (PR) cans; the PR cans were placed into larger canisters for transport via roadway to Hanford's 231-Z Plutonium Isolation Building or the 234-5Z Plutonium Finishing Plant for further processing.

Several significant processing upsets took place during the 233-S Facility's active operations. In 1956, failure of an air-activated diaphragm valve resulted in the release of approximately 32 grams of plutonium solution to the floor of the 233-S Building's process hood, with subsequent spread of contamination to the REDOX Facility. In 1963, chemical reactions within an anion-exchange concentrator resulted in a rapid pressure increase and the release of plutonium-laden resin beads. This, in turn, ignited a fire that burned for 90 minutes, causing extensive damage to process equipment, damage to the ventilation system filter, a spread of gross alpha contamination within the process area, and distribution of radioactive contamination to other portions of the building's interior and the exterior roof surfaces. Between 1 to 3 kilograms of plutonium were lost as result of this fire. Following extensive cleanup, and construction of the 233-SA Exhaust Filter Building, the 233-S Facility resumed operations until 1967.

Between 1967 and 1987, limited efforts were made to perform initial characterization of the facility and remove selected equipment and material from the building's load-out area. After 1987, the facility sat idle for nearly another decade.

As part of the CERCLA decision process, a report entitled *Engineering Evaluation/Cost Analysis for the 233-S Facility* (DOE-RL, 1997a) presented four optional approaches for further facility management. For each option, the resulting levels of safety were projected. Decontamination and/or stabilization of the facility, followed by demolition and disposal, was selected as the approach most responsive to safety concerns and the most supportive of planned land remediation actions (DOE-RL, 1997b).

From 1997 to 2002, Bechtel Hanford, Inc. completed a significant amount of decommissioning scope including the removal of equipment from the process and non-process areas of the 233-S Building. In addition to installing a portable exhauster, this scope included removing roof-mounted ventilation ducting, process area viewing room support structure, 14 process vessels, nearly 1,500 m (5,000 ft) of process piping, and other equipment from the equipment room, control room, and other areas of the facility.

In July 2002, responsibility for decommissioning the 233-S Facility was transferred from Bechtel Hanford, Inc., to Fluor Hanford.

DEMOLITION PREPARATIONS

After assuming contractual responsibility for demolishing the 233-S Facility in mid-2002, Fluor Hanford focused the following 12 months on final removal of equipment, limited decontamination, initial radiological characterization of the building's structural materials, application of fixative coatings to "lock-down" the potentially dispersible contamination, deactivation of the portable ventilation exhauster system, and removal of temporary power and lighting services.

During the summer of 2003, Fluor Hanford's procurement organization issued requests-for-interest and proposals to provide technical support and a limited amount of equipment for the demolition of the 233-S Facility. A contract was subsequently issued by Fluor Hanford to cr/x environmental services℠, inc. (hereafter referred as cr/x), of Coraopolus, Pennsylvania. The D&D consulting services and specialized heavy equipment hired from cr/x were supported by subcontracted engineering services from Burns & Roe of Oradell, New Jersey, and concrete-sawing expertise from Cutting Edge Services Corporation of Cincinnati, Ohio.

The following subsections describe the preparatory efforts prior to the start of demolition in October 2003.

Radiological Characterization

Extensive radiological surveys and nondestructive assay (NDA) measurements were performed during the various stages of equipment and material removal from the 233-S Facility in 2002 and early 2003. A final sampling plan was developed and implemented in mid-2003 to support (1) waste disposal planning for the purposes of minimizing the volume of TRU waste, and (2) evaluation of specific demolition techniques to minimize the release of radiological material during the demolition process. As noted in Table 1, the total mass of TRU isotopes within the 233-S Building had been estimated at 13.4 grams (Mantooth, Barton, and Moder, 2003), with the majority of contamination located on the west and north walls of the 233-S process hood. This mass relates to contamination levels in the process areas in excess of 33.4 MegaBecquaerrels (MBq)/m^2 (20x10^6 dissintegrations/min/100 cm^2). The isotopic distribution of TRU within the 233-S Building is summarized in Table 2.

Table 1. TRU Mass Estimates for 233-S Locations

Location	TRU (grams)
Can Storage Room	0.061
SWP Change Room	0.054
Pipe Gallery	0.141
PR Can Storage Room	0.039
PR Can Loadout	0.081
Stairwell – 1st Floor Wall	0.024
Stairwell – 2nd Floor Wall	0.055
Stairwell – 3rd Floor Wall	0.026
Stairwell – 4th Floor Wall	0.018
Stairwell – 1st Floor Landing	0.023
Stairwell – 1st Floor Landing	0.049
Stairwell – 1st Floor Landing	0.037
Stairwell – 1st Floor Landing	0.016
Stairwell – Ceiling	0.002
Process Hood – West Wall	5.682
Process Hood – North Wall	6.175
Process Hood – South Wall	0.038
Process Hood – East Wall	0.828
Process Hood – Ceiling	0.037
Total	13.39

Table 2. Isotopic Weight Distribution as Determined through Sampling and Analysis Data (w_i = weight of isoptope; w_T = total weight of measured isotopes; w_{TRU} = weight of transuranic isotopes)

Isotope	Weight Fraction (w_i/w_T)
Plutonium-238	0.0007
Plutonium-239	0.8405
Plutonium-240	0.1046
Plutonium-241	0.0074
Plutonium-242	0.0059
Americium-241	0.0108
Neptunium-237	0.0301
	w_{TRU}/w_T=0.9926*

* w_{TRU} includes all isotopes listed above, except for plutonium-241 since it is not a TRU isotope.

Radiological Analysis of Demolition Techniques

Characterization data (as referenced above) were utilized for purposes of waste designation, and for performing radiological analysis of demolition techniques. The Hotspot 2.01 (Hotspot, 2002) atmospheric dispersion computer code was utilized to estimate the downwind personnel-committed-dose and surface contamination levels that would result from four different demolition techniques (Knight and Mantooth, 2003). These techniques included demolition via the use of (1) a wrecking ball, (2) mechanical shear, (3) circular diamond-blade wall sawing, and (4) continuous diamond-wire sawing. Historical averages for Hanford Site wind speed and stability class were used for the model. The wrecking ball method demonstrated the greatest potential for generating airborne contamination, followed in order by mechanical shearing, circular diamond- blade wall sawing, and continuous diamond-wire sawing.

As reflected in Table 3, for a given quantity of radioactive material at risk, use of the circular diamond-blade or wire saws would result in a level of downwind contamination two-to-three orders of magnitude less than the more aggressive techniques. Values for use of a wrecking ball are not noted below, as that method was not considered for further evaluation because the method was not approved for use under the facility's safety basis.

Table 3. Evaluation of Demolition Methods

Demolition Method	Maximum CEDE* (rem)	Maximum Alpha Contamination (d/min/100cm2)	Distance to Max. (km)
Mechanical Shearing	2.1	1.8E+05	<0.01
Circular Diamond-Blade Wall Sawing	0.56	460	<0.01
Continuous Diamond-Wire Sawing	0.046	500	<0.01

*CEDE = Committed effective dose equivalent

The values noted in Table 3 compare unmitigated releases resulting from each demolition method. Mitigation techniques such as pre-decontamination, water misting/fogging, fixative applications, or other engineered methods would further reduce the potential for release of radioactive material.

Demolition Method Selection

Initial concepts for removing the 233-S Facility involved decontamination of the facility's interior surfaces, followed by the use of conventional demolition techniques (e.g., use of a concrete shear to demolish and size-reduce all building structures and material). In November 2002, a company was subcontracted to provide decontamination services using an ultra-high-pressure (i.e., 30,000 pounds per square inch) hydrolaser washing system that included a shrouded applicator and vacuum recovery system. The use of this decontamination technique was terminated in January 2003 after experiencing difficulties related to protrusions from the wall and other irregular surfaces and the ability to reliably accommodate the many types and layers of fixative materials that pre-existed on the building wall surfaces. The decision was made that a more conservative and controlled demolition approach was necessary to safety protect the D&D workers, employees at neighboring facilities, and the environment.

Based on an April 2003 value-engineering session (Parker, 2003) involving input from all levels of 233-S Facility staff, a proposed plan from cr/x, and other planning efforts, an acceptable demolition approach was developed for the 233-S Facility. The selected approach involved using an excavator equipped with a concrete-shear attachment to size-reduce the single-story and less-contaminated portions of the 233-S and 233-SA Buildings. The selected approach also involved use of circular diamond-blade wall saws for cutting the taller and more contaminated portions of the 233-S Facility (i.e., process hood) into large, rectangular blocks that were then lowered to ground level via crane.

After the combined shearing and sawing approach was selected for 233-S Facility demolition, a decision was made to perform additional and more detailed atmospheric dispersion modeling to confirm that the work could be performed without releasing alpha contamination beyond the contamination area (CA) boundary in excess of 33.4 Bq/m^2 (20 d/min/100 cm^2). The dispersion modeling was performed by AlphaTrac of Westminster, Colorado, using ISC-PRIME (an EPA-developed program that uses actual weather conditions). The ISC-PRIME code was considered more applicable for modeling potential atmospheric releases from 233-S than the previously used HotSpot 2.01 code, for the following reasons: (1) it uses actual site weather conditions reported hourly; (2) it has algorithms that account for the building "downwash" generated by the 202-S REDOX Plant; and (3) releases to the atmosphere from demolition activities could be matched to time of release and actual weather conditions, providing a more accurate picture of where potential contamination would occur.

The ISC-PRIME dispersion modeling results indicated that all areas with contamination levels exceeding 33.4 Bq/m^2 (20 d/m/100 cm^2) would lie within a 40 meter-radius CA boundary as measured from the center of the 233-S process hood. These analyses helped to reaffirm that this first-of-its-kind open-air demolition project should proceed as planned.

DEMOLITION OPERATIONS

Demolition operations at the 233-S Facility began in mid-October 2003. The mobile office MO-317, the 233-SA Building and the single-story portions of the 233-S Building were safely demolished via shearing methods, packaged, and buried in the ERDF landfill. This scope was accomplished by late December 2003. Between the months of January 2004 and April 2004, the highly contaminated 233-S process hood was dismantled via block cutting and removal techniques, and all associated waste was packaged and either buried in the ERDF landfill or placed in temporary storage at Hanford's Central Waste Complex for eventual disposal at WIPP. All demolition scope was accomplished without any release of contamination outside of the controlled area.

The following subsections describe a number of the controls established to accomplish this work and the general approach employed.

Radiological Controls/Engineering

A variety of radiological controls were established to protect the D&D workers, and to prevent the spread of contamination outside of the CA (Mantooth, 2003). As noted earlier, the CA boundary was established at a 40-meter (131-ft) radius from the center of the 233-S process hood. A radiological buffer area was also established 10 meters (30.5 ft) beyond the CA boundary to allow for staging of supervisory personnel, waste containers, and a variety of support equipment.

Fugitive dust emissions from the breaking and/or packaging of concrete rubble were controlled by use of water-efficient misters and foggers (i.e., MARTIN® FOG CANNONs™) that were positioned on two sides of the demolition activity to provide light and general-area misting; each unit delivered approximately 53 liters/min (14 gal/min). A low-flow, 9.5 liters/min (2.5 gal/min) misting system head was designed by cr/x and installed directly into the excavator arm, with nozzles positioned at the throat of the shear. The design, which localized a concentrated mist directly into the cutting action of the shears, proved to be extremely effective. Dust suppressants (e.g., Soil-Sement® solutions) were also applied prior to shut-down periods and prior to any anticipated high-wind conditions.

Engineered controls were established for capturing the potentially-contaminated water that was generated while cooling/lubricating the circular diamond-saw blades as they dissected the highly contaminated process hood into large blocks. Prior to the start of shear demolition operations, the predetermined saw-cut pattern lines were marked on the interior wall and ceiling surfaces of the process hood. A network of metal gutters was then installed via powder-actuated fasteners to cover each of the saw cut lines on the inner wall and ceiling surfaces; the gutters were positioned to drain to a common manifold for water collection and disposal. To address the need to capture the potentially contaminated saw cooling/lubrication waters on the exterior of the process hood, cr/x developed a uniquely designed shroud that attached directly to the saw as it cut along the concrete surfaces. A set of saw receiver shrouds were also created for attaching directly to the ends of the saw track to capture concrete slurry as the saw blade traveled beyond the corners, openings, or ends of the structure as it completed the saw cuts.

Wind conditions were continually monitored via windsocks, a nearby weather station, and hand-held anemometers. All workers and support equipment were required to be located upwind of the demolition activity and at a distance sufficient to prevent inadvertent contamination should the wind direction change. The maximum allowable wind speed for demolition operations was 12 miles per hour.

Personal protective equipment (PPE) requirements for all demolition and support personnel within the CA included a single set of radiological PPE clothing, waterproof rain gear, and a Power Air Purifying Respirator (PAPR) with hood. A Hanford standard dosimeter and a lapel air sampling pump were also required for radiation monitoring of personnel. Contamination surveys and air monitoring were routinely performed via three grab-air samplers, five continuous air monitors, 18 fixed-plate survey stations, and CA exit surveys of personnel and equipment.

Phase 1 Demolition -- Shearing Operations

During the period of late October 2003 to mid December 2003, the MO-317, the 233-SA Building, the single-story portion of the 233-S Building, and the four-story stairwell (connected to the 233-S process hood) had been completely and safely demolished via shearing.

The shearing operations were accomplished using a 45,000 kg (100,000 lb) CAT® hydraulic excavator equipped with a 12×10^6 newton (1,300 ton) rotating mechanical shear. The demolition sequence began with the MO-317, as previously noted in Figure 2. Demolition and waste packaging/disposal of this relatively benign structure demonstrated that all equipment, personnel, dust suppression systems, and waste-loading procedures were indeed prepared and ready to proceed immediately to the more contaminated 233-SA Building.

Since nearly all of the structures demolished during the shearing phase of the project (with exception of the four-story stairwell) were less than 3.6 m (12 ft) from grade level, all building material removed by the excavator were generally directed onto the interior slab surface. Protection of adjacent building and structures (e.g., an electrical transformer on the east side of 233-S, and an underground pipe trench located on the west side of 233-S) from falling rubble was established via nylon netting barriers and other materials prior to the start of demolition.

After the 233-SA Building was demolished and its waste was loaded, demolition of the 233-S Building proceeded from northeast to southwest. Photographs in Figure 3 depict the field settings during demolition of the 233-SA Building and weeks later when the excavator was demolishing the four-story stairwell on the east side of the 233-S process hood.

Figure 3. Images during demolition – left photo depicts demolition of the 233-SA Building (note the FOG CANNON™ in lower left of the image and the ERDF waste container in center); right photo depicts subsequent demolition of the 233-S process hood stairwell.

Loading of concrete into the lined ERDF waste containers, each 2.4-m wide x 6.1-m long x 1.8-m high (8 ft wide x 20 ft long x 6 ft high), was performed whenever a sufficient quantity of rubble was generated. The rubble piles were kept wet at all times. The concrete rubble was loaded into the ERDF containers using a front-end loader. The structural steel and metal siding associated with the process hood stairwell were primarily loaded into the ERDF containers via the grappling capability of the shear jaw. A total of 65 ERDF containers was used to package and dispose of all debris generated during demolition of MO-317, the 233-SA Building, the lower portions of the 233-S Building, and the stairwell attached to the 233-S process hood.

Phase 2 Demolition – Sawing Operations

Removal of the highly-contaminated 233-S Building process hood began in January 2004 and was completed in April 2004. This task was accomplished by segmenting the process hood structure into pre-engineered panels using track-mounted, diamond-blade wall saws. Photos of initial and intermediate states of saw cutting are shown in Figure 4. After each rectangular panel was cut, it was lowered via crane, and then prepared for disposal. Most panels were wrapped in plastic and polypropylene bags (supplied by MHF Logistical Solutions) and transported for disposal as LLW at the ERDF site. Designated panels from the lower northwest portion of the process hood were classified as TRU waste, and were packaged and transported to Hanford's Central Waste Complex. The TRU waste will eventually be disposed at the WIPP Site in Carlsbad, New Mexico.

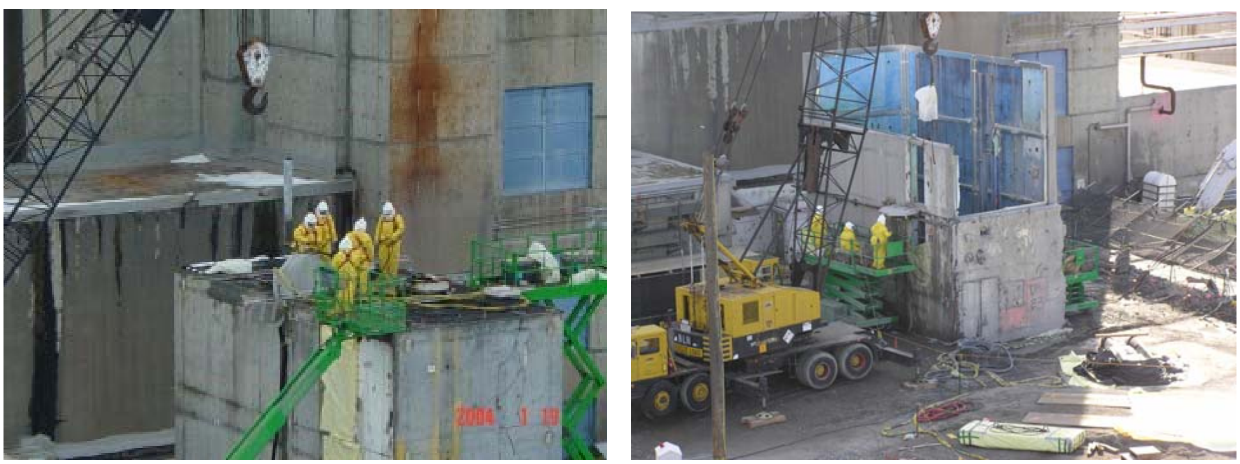

Figure 4. Photos of wall-saw cutting on 233-S process hood – left photo depicts shrouded concrete wall saw at the beginning of a horizontal roof cut; right photo depicts the saw being set up after 11 blocks had been cut and removed.

A detailed cutting plan was prepared to ensure that integrity of the roof and wall structures was maintained during the segmentation and crane/rigging evolutions. The reinforced concrete wall and roof sections were 30.5 cm (12-in.) thick; the largest of panels were cut to 2.4 m x 4.6 m (8 ft x 15 ft), weighing approximately 9,000 metric tons (20,000 lb). Over 80 cuts were necessary to fully segment and remove the process hood structure. The total length of cutting was in excess of 275 m (900 ft).

Before demolition operations began in October 2003, a core-boring drill was used to create a number of through-holes in predetermined location to install lifting hardware. These holes were installed in the roof and on all accessible/exposed locations on the walls of the process hood. After the stairwell and single-story portions of 233-S Building were demolished, the remaining holes were installed. As discussed earlier, some of the additional preparations for saw cutting included the installation of gutters on the interior walls of the process hood to capture the cooling/lubrications waters that sprayed-off from the rotating saw blades during the final break-through cuts. Expertise on the saw cutting operations was provided by Cutting Edge Services Corporation. Representatives from Cutting Edge provided the services of equipment operations, training of Hanford's D&D workers, and technical support.

Post Demolition Tasks

During the months of May through June 2004, a wide variety of tasks were performed to support project closeout. Initial efforts were focused on decontamination of the demolition support equipment so that it could be removed from the 233-S project site and reused on future D&D projects at Hanford. Temporary utilities, support trailers, and storage containers were removed from the site. Miscellaneous waste was packaged and shipped for disposal. Radiological surveys of the demolition site were performed, and a clean layer of gravel was placed over areas surrounding the 233-S Facility's floor slabs. The floor slabs were also covered with clean gravel, a thin (approximately 100 cm [four inches]) concrete cap, and additional gravel on top of the concrete cap. The demolition zone was then posted as an underground radioactive material area. Project files were submitted for records retention purposes, and the facility's engineering drawings were updated and/or reclassified as "Inactive" within the Hanford Document Control System. Figure 5 depicts the project site before and after demolition.

Figure 5. Photos of 233-S Facility area before and after demolition:
left photo dated October 2003; right photo dated June 2004.

LESSONS LEARNED AND INNOVATIVE WORK PRACTICES

The experience and knowledge gained from this demolition project are important to the Hanford Site as additional plutonium facilities are scheduled for demolition in the near future. Other sites throughout the DOE Complex may be faced with similar challenges.

Since this project represented a first-of-a-kind effort for the Hanford Site, one of the most important aspects of the approach to demolition was the commitment to pay close attention to emergent issues and to take the time to analyze their impact(s). Resisting the urge to push forward before understanding and mitigating issues was very valuable and avoided many potential problems.

During all phases of this demolition project, numerous innovations, effective work practices and lessons learned were implemented. Accordingly, a series of "Lessons Learned and Innovative Practices Fact Sheets" have been developed and are provided in the appendix of this report. The intent of the appended material is not to capture every innovation and lesson learned, but rather to describe those that the project believes to be of most benefit to future DOE projects. These fact sheets cover a broad range of topics within eight general categories including: project management, organization structure and distribution of responsibility, demolition approach and equipment, planning and scheduling, site preparation and infrastructure, radiological controls, industrial safety and health, and waste handling.

Each fact sheet in the appendix includes a "Situation" section to provide the reader with brief background, an "Analysis" section to summarize what did or did not work well, and a "Considerations for Future Projects" section that offer suggestions for future project managers who are faced with similar situations. If the reader is interested in obtaining additional information, names and phone numbers of knowledgeable 233-S Facility Demolition Project representatives from within Fluor Hanford and the U.S. Department of Energy are provided at the end of each fact sheet.

SUMMARY AND CONCLUSIONS

This project represented the first open-air demolition of a highly-contaminated plutonium facility at the Hanford Site. This project may also represent the first plutonium facility in the DOE complex to have been demolished without first decontaminating surfaces to near "free release" standards. The decision to perform or not perform extensive decontamination of wall, floor, and ceiling surfaces prior to demolition of radioactively contaminated facilities presents significant trade-offs in cost, schedule, and risk.

The 233-S Facility has been successfully removed without significant release to the environment and without recordable personnel injury. The lessons learned and innovative practices that were experienced on this project should be of interest and benefit to future D&D projects at Hanford, other sites throughout the DOE complex, and the commercial sector.

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Trademarks

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APPENDIX -- Lessons Learned and Innovative Work Practices Fact Sheets

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PROJECT MANAGEMENT
Investment in Heavy Equipment

"Subcontracting of demolition equipment and/or services may not prove to be cost effective"

Situation

The "purchase versus lease" decision for nuclear facility demolition equipment is not always straightforward.

If heavy equipment is needed for a number of contaminated-facility demolition projects, purchasing (rather than leasing) may be more cost effective.

During the planning phase for the 233-S Facility Demolition Project, it was determined that Fluor Hanford (FH) did not own an excavator, and other contractors at the Hanford Site did not possess any heavy equipment that could be committed for the timeframe during which the 233-S Facility demolition activities would be performed. Based on the Site's interest to infuse more commercial nuclear practices into the Hanford Site, a decision was made to pursue renting/leasing of some demolition equipment.

After inviting a large number of potentially interested companies to information meetings on 233-S Facility demolition scope, and issuance of requests for proposals, a subcontract was awarded. This subcontract included demolition consulting/technical support services, saw cutting services, and leasing of a previously contaminated excavator and an excavator operator. Access to a previously contaminated (and regulated) excavator was attractive to FH since such equipment is not only difficult to locate in the commercial sector, but also because the risk associated with the possibility of not being able to decontaminate the excavator to acceptable levels after its use was greatly reduced. The subcontract was based on a provision (imposed by the subcontractor) that the excavator would be operated solely by a subcontractor-provided operator rather than by a Hanford Site employee. This issue was somewhat complicated by the fact that a Hanford Site decision (based on application of the Davis Bacon Act) had already been made that work scope such as that being considered for the 233-S Facility should be performed by Hanford's organized labor work forces. Consequently, some negotiations with the local work forces were necessary to allow the subcontractor to be the exclusive operator of the excavator.

Analysis

In the case of the 233-S Facility Demolition Project, the initial objective of renting/leasing an already contaminated piece of equipment was prudent. No other equipment was available from Hanford's onsite equipment pool. In hindsight, it would likely have been more cost effective to have leased only the excavator (not the excavator operator and excavator support personnel), or to have purchased an excavator; an excavator operator and supervisory personnel could have been provided by Hanford Site forces. As the scope and duration of the overall project increased, the costs for the subcontracted excavator operator and excavator support personnel increased accordingly.

Unless the rules that establish the jurisdiction of the work at the Hanford Site are changed, the Site's purchase of heavy equipment for contaminated building demolition would likely be more cost effective than subcontracting such equipment.

Considerations for Future Projects

- Trade-off evaluations for having the subcontractor supply/lease equipment to the project versus direct equipment purchase should be performed.
- If renting/leasing of heavy equipment is desired, contracts for equipment (not equipment and operators) should be considered. Expertise in alpha-contaminated facility demolition is not easily obtained. Opportunity for leasing of contaminated equipment is very limited.
- Since work involving alpha contamination is very unique, due diligence on a subcontractor's record of work in nuclear applications (including experience with specific types of contaminants) should be performed.
- If Davis Bacon Act determinations require the Site's forces to perform work, it may be difficult to be cost effective when mixing subcontractor-provided field support with Site labor.
- Any delays in a project's schedule (e.g., due to weather, technical issues, and regulatory issues, etc.) will extend the duration of the equipment lease, thus making the cost/benefit less attractive.
- Maintenance schedules for leased equipment are not normally tracked by the project's/Site's equipment maintenance programs. Extra care and attention are needed to ensure that all maintenance requirements and expectations are met.
- Stand-by rates for equipment should be thoroughly evaluated during contract development. The influence of weather on the 233-S Project incurred higher stand-by payments than anticipated.
- If subcontracted equipment is utilized, the site acceptance and operational requirements should be clearly defined. Relevant issues for consideration include: Underwriter's Laboratory/National Electrical Code listings, Occupational, Safety, and Health Act of 1970 compliance, disposal of fluids if required, maintenance/disposal of spare or faulty parts, and preparations for contamination removal.

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PROJECT MANAGEMENT
Technical Baseline Controls

"Strict controls on the technical baseline helped to stabilize the project."

Situation

Innovative ideas were encouraged from team members, but special controls were also needed to firmly establish the 233-S Facility's technical baseline. Once established, any changes to the baseline plans were formally controlled.

It was known for some time that regardless of the final techniques chosen for demolition of the 233-S Facility, certain core activities (e.g., removal of equipment, removal of stored waste, application of fixatives to interior surfaces, characterization of interior surfaces, shutdown of utilities, etc.) would have to be performed to prepare the building for safe demolition. As these demolition preparation tasks were being performed in the field, demolition planning was also being performed as a parallel activity. This demolition planning effort entertained a variety of demolition concepts ranging from concrete shearing within large tents, to doing the same without a tent, to the use of diamond blade and/or wire sawing methods, and various combinations of these and other methods.

Innovative concepts were encouraged from all members of the immediate project staff as well as from supporting organizations (e.g., engineering, radiological control, industrial safety, etc.). However, due to the large number of options being suggested, there was a point when it became difficult to keep all workers focused on the right preparatory activities. Eventually, this free flow of new ideas needed to be contained, and a technical baseline "locked-in" and then managed by configuration control. The project's management team then established a project baseline that provided clear direction in each of the following areas:

- Demolition methods for each portion of the facility.
- Pre-demolition end-states (required before demolition could begin).
- Techniques to be utilized to reach each end state.
- Controlling work documents that would be required to approve each group of activities.
- Special radiological controls that would be required for each activity.

In addition to establishment of this technical baseline, the management team set an expectation that (without specific approval from the director) there would be no time spent on anything that was not in direct support of the technical baseline. This, along with clear expectations for progress and deliverables from each staff member supporting the technical baseline, brought the appropriate degree of focus to the project.

It was recognized that this approach had the obvious benefit of focusing the project, but also had the potential to stifle new and innovative ideas. These types of ideas had been encouraged previously; and all direct and indirect staff felt they were part of the team and had a voice in the project's direction. When the technical baseline was established, direction was given to the entire team that new ideas were still encouraged, but prior to anyone pursuing those ideas for more than one hour, approval of the Project Director, Manager of Demolition Preparations, or Manager of Demolition was required. The authorizing manager was responsible for ensuring that enough time was given to explore the ideas without causing loss of momentum on the approved plan. When (and if) the authorizing manager was convinced that the new approach would be a benefit to the project, the Project Director was briefed and a determination was finalized on the path forward. If an alternative pathway was approved, only then was the technical baseline revised.

Analysis

After applying heightened controls on the evolving plans, and strictly enforcing the rules for change, the project was able to focus its limited resources and still give personnel the ability to bring innovative practices and good ideas "to the table."

Considerations for Future Projects

- It is important to formally establish configuration control for a project's baseline plan even if some areas are not yet well defined.
- First-of-a-kind activities warrant solicitation of new ideas and concepts from all members of a team.
- Controls should be established and communicated regarding the amount of time and energy that can be applied to developing alternative concepts for a given project.
- If controls are correctly established, innovation can be encouraged while not allowing the project to lose focus.

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PROJECT MANAGEMENT
Size of Work Packages

"Work packages for controlling demolition scope need to be appropriately sized."

Situation

As the Hanford Site transitions from operating nuclear facilities to removal of excess nuclear facilities, the demolition projects must determine the best methods for defining and authorizing the discrete elements of demolition work scope.

Work packages for demolition activities can effectively encompass a broad range of scope if job hazards are appropriately identified and managed.

During the planning phases for the 233-S Facility Demolition Project, it was recognized that the standard operating procedures that are typically used to describe repetitive processes and the controls necessary for hazard mitigation were not flexible enough for the changing conditions that exist on a demolition project. It was also recognized that the very task-specific work packages that are typically used to authorize maintenance and repair work in nuclear facilities were too restrictive because they followed a script of pre-requisite conditions, system line-ups, repair instructions and retest parameters, etc. Neither model (i.e., the standard operating procedures and the work packages typically used for maintenance tasks) represented ideal models for demolition scope.

Analysis

A modified version of the maintenance work package model was adopted for 233-S Facility demolition preparations and for actual demolition. The project team used the project's technical baseline (discussed in a separate fact sheet) to help define and develop reasonable breadth of work for each work package. Of course, there still remained a subset of activities that fell under the typical routine maintenance work package model (e.g., monthly inspections of emergency lighting and calibration of hand and foot radiation monitors, etc.), and the standard operating procedure model for other routine tasks (e.g., daily checks of an exhaust system and use of cold weather protection checklists).

The 233-S Facility demolition work scope was first grouped into major categories, and then each scope of work was reviewed by the team using site tools for hazards analysis and appropriate controls. An example of the types of tasks grouped within a work package would be as follows:

- Demolition Preparation
  - Size reduction of building waste material
    - Use of typical hand tools for size reduction
    - Contamination control techniques for size reduction

- Waste packaging
  - Proper packaging techniques
  - Contamination controls for packaging
- Removal of facility equipment and structural components.
  - Use of appropriate tools for structural steel removal
  - Proper use of aerial lifts for elevated work
  - Use of secondary ventilation for contamination control during removal process.

Each subcomponent for such a given work package was reviewed by the project team; hazards were identified, mitigation techniques determined, and work instructions developed and approved. This approach resulted in work packages that had slightly larger scope and incorporated a number of different tasks. While this type of work package necessitated very thorough pre-job briefings, it proved to be effective. Any changes in scope definition required specific reviews for potential impacts to the hazards analysis and mitigation methods. This approach served the project well.

Considerations for Future Projects

- Typical operating procedures or maintenance work packages do not work well in a D&D environment.
- Work packages for general D&D work need to give flexibility while controlling hazards to the workers and to the environment.
- When developing work packages with substantial breadth, project personnel with the greatest amount of applicable experience should be utilized. Daily pre-job briefings and change controls are also extremely important.
- Job Hazard Analyses can and should be performed at the sub-activity level when controls are not applicable to all steps within a given work package.
- Field Work Supervisors need to be especially vigilant in knowing boundaries of their work authorization.

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PROJECT MANAGEMENT
Turnover of Project Scope

"Transferring of key personnel and detailed project baselines are important elements of DOE contractor turnover."

Situation

On July 1, 2002, personnel and a large number of Hanford facilities were transferred from Bechtel Hanford, Inc. (BHI), to Fluor Hanford (FH). This realignment of scope supported Hanford's long-term strategic plan for Site contractor responsibilities. This transfer of work included Hanford's groundwater management program and hundreds of radioactively contaminated waste sites and buildings located in Hanford's Central Plateau (i.e., Hanford's 200 East and West Areas). The 233-S Plutonium Concentration Facility was one of the many facilities transferred as part of this realignment.

During the change of contractors in July 2002, only a small number of employees transitioned with the 233-S Facility. Consequently, a new D&D organization (e.g., project managers, engineers, planners, schedulers, safety, D&D workers, etc.) had to be staffed and a detailed baseline needed to be developed for this demolition project.

From late-1997 through mid-2002, BHI accomplished a significant amount of difficult work involving the removal and disposition of contaminated ducting, piping, vessels, and other plutonium process equipment from the 233-S Facility. However, when the facility was transitioned, only about one-third of the facility's staff transferred from BHI to FH. Consequently, a substantial amount of facility and process knowledge were lost during the change in contractors.

Analysis

A transition plan was developed for the 2002 transfer of work from BHI to FH. This transition plan was jointly and cooperatively developed by FH and BHI months before the July 2002 transition date. A number of lessons were learned during the overall transition process and are described in Lessons-Learned report, *2002-RL-HNF-0056, Central Plateau Transition*. Two of the lessons which had direct impact to the 233-S Facility, involved the loss of facility knowledge due to the transfer of a limited number of personnel and the turnover of a detailed project baseline.

Many of the BHI employees (exempt, non-exempt, and bargaining unit staff) who previously supported the 233-S Facility were reassigned or requested reassignment to other BHI projects in the months prior to the July 2002 transition date. Consequently, much of the experience base that BHI developed during the period of 1997 to 2002 did not transfer to FH. FH needed to obtain a project manger, supervisors, engineers, planners, schedulers, bargaining unit staff, and other specialized personnel from a variety of other FH projects to rebuild the 233-S Facility organization.

Additional time and expenses were also incurred as a result of the need to develop a sufficiently detailed baseline for future work at the 233-S Facility. Since BHI knew that it was transitioning the facility to FH, BHI was not obligated by contract to develop and maintain a detailed project baseline beyond its known period of operation. During development of the Central Plateau Transition Plan, FH assumed that all work would be transitioned with a baseline (i.e., scope, schedule and budget) already prepared. Had FH known about the lack of a sufficiently detailed baseline during the transition planning phase, a specific task to utilize the existing facility knowledge base and develop a detailed baseline could have been incorporated into the Central Plateau Transition Plan.

Considerations for Future Projects

- When transferring work scope from one DOE contractor to another, the transition plan should include a specific sub-task that requires the transfer and/or co-development of a sufficiently detailed project baseline (i.e., scope, schedule, and budget) prior to transition.
- During work scope transfers between DOE contractors, key salaried employees should be made available and encouraged to transition with the work scope. Otherwise, valuable project experience might be lost. If employees do not transfer with the work scope, the cost to the government increases (i.e., one organization needs to hire and train replacements and the other organization may need to retrain the retained employees to perform other work). The transition activities should include a specific impact analysis on the loss of facility or program experience.

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ORGANIZATION STRUCTURE & RESPONSIBILITIES
Accountability for Upgrades to D&D Equipment

"Assisting subcontractors with their equipment problems can dilute their accountability."

Situation

During the 233-S Facility Demolition Project planning, a contract was issued to a deactivation and decommissioning (D&D) services company to provide technical support, an excavator and operator, wall-sawing equipment and operators. Due to schedule constraints (partly in an attempt to avoid the worst of winter weather conditions), the project management allowed some of the subcontractor-provided equipment to be received onsite even though the equipment did not fully meet the specifications as stated in the contract. The project subsequently worked with the subcontractor to jointly rectify discrepancies noted with the subcontractor-provided equipment

The project occasionally worked with equipment suppliers and subcontractors to expedite modifications necessary to certify equipment as field ready. This action by the project diluted supplier and subcontractor accountability. Greater adherence to contract language regarding specifications for subcontractor-provided equipment could have minimized the upgrades that were performed on-site.

Analysis

Because of the project's compressed schedule, the Project decided that acceptance of the subcontractor-provided equipment onto the Hanford Site "as is" and working through the issues would provide a better path to meet the project's goals. In hindsight, the project should have ensured that equipment met all contract requirements prior to it being brought on-site. In some cases, this approach might have taken more time, but could have avoided several issues regarding work performed by the subcontractor vs. work performed by the Site's workforce. Currently, demolition equipment on the Hanford Site is typically maintained by the Site's craft labor.

Considerations for Future Projects

- Contracts should clearly state any special equipment requirements. Detailed checklists should be provided within contracts to ensure there is a clear understanding of what is required and what will be checked prior to onsite acceptance.
- If equipment is leased, a process must be in place to ensure that the equipment meets the standards for the job and any costs and requirements (e.g., National Electrical Code [NEC] and the Occupational, Safety, and Health Administration [OSHA]) are met prior to onsite receipt and acceptance.
- Particular attention should be dedicated to the issues surrounding NEC, OSHA, and other electrical inspection requirements. Specialized/custom equipment and some commercially

available, off-the-shelf equipment may not have the necessary certification that is required for use on the Hanford Site. If changes are made to the equipment in order to accommodate specific job requirements, existing certifications could be voided.

- Mixing labor types (onsite vs. subcontracted) can make it difficult to perform the work in an efficient manner.
- Contracts written for use of leased equipment in a radiation area should include requirements for the subcontractor to prepare the equipment for the respective rigor of the job. For example, the subcontractor's excavator was repainted just prior to field use to assist with decontamination of the equipment upon completion of the job. This investment saved time in the long run. Overall, the excavator was easy to clean and any contamination found on the painted surfaces was easy to remove.
- When evaluating the suitability of a given piece of equipment, consideration should be given to the length of time that the equipment had been sitting idle since its previous job. Additional maintenance and time are often necessary to get a long-idled piece of heavy equipment back into top operating condition.
- Before allowing equipment to enter a radiation zone, every effort should be made to ensure the equipment is in good operational condition; equipment maintenance, spills, and breakdowns are much more complex once the equipment enters the zone.

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ORGANIZATION STRUCTURE & RESPONSIBILITIES
Subcontracting Radiological Control Technicians

"Subcontracting of offsite RCTs was straightforward and effective."

Situation

In the fall of 2003, a decision was made to expand field operations on the 233-S Facility Demolition Project from one shift per day to two shifts per day. This decision was made to take full advantage of the lower wind conditions that were expected during the early morning hours (based on review of historical weather data), and to accomplish as much demolition as possible before the onset of winter conditions. To support the second work shift, additional Radiological Control Technicians (RCTs) were needed.

RCTs are in high demand at the Hanford Site. To support short-term needs during peak activity, experienced RCTs were hired on a temporary basis.

Fluor Hanford had a pre-established agreement in place that allowed for the hiring of temporary radiological control personnel from Bartlett Services if Fluor Hanford's existing staff could not support the RCT need.

Analysis

Since RCTs were in short supply at the Hanford Site, the option to hire temporary support was exercised. Within a two-week period, 12 RCTs were hired on a temporary contract, provided with Hanford Site-specific training, and placed in the field. All RCTs were competent and worked shifts necessary to support the Project's needs. When the temporary additional personnel were no longer needed, the contracts were terminated.

Considerations for Future Projects

- Pre-established agreements (including union approval) for obtaining temporary support during short period of peak demand can be very beneficial to a project and relatively easy to exercise.
- A number of contractors that support the nuclear power industry within the United States offer experienced personnel on a temporary basis.

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ORGANIZATION STRUCTURE & RESPONSIBILITIES
Dedicated Craft

"Efficiencies were realized after dedicating craft support to the project."

Situation

During conceptual planning for 233-S Facility Demolition Project, a number of different options were considered for executing field work. Each option involved a slightly different mix of labor resources.

Establishment of dedicated craft support, and the priority to obtain craft resources on an as-needed basis, were essential to the 233-S Facility Demolition Project.

One approach that was considered during the conceptual planning phase involved subcontracting the entire project to an outside demolition services company. Under this scenario, Hanford's on-site labor would have been minimally involved and nearly all demolition work would have been performed similar to a turn-key construction project. Due to considerations such as Davis-Bacon Act interpretation, local labor agreements, and the fact that this was a first-of-a-kind-effort for the DOE complex, this option was not pursued.

The concept that was chosen involved the use of a demolition services subcontractor that provided consulting and field supervisory services as well as a leased excavator and excavator operator. Aside from these contracted services, all supporting work was provided by Hanford's resources. An organized labor category known as the Deactivation and Decommissioning (D&D) worker was staffed to perform a variety of D&D labor tasks. The project management's initial understanding of scope that could be performed by the D&D workers (e.g., shoveling of sand/gravel, cutting of pipes, or removal of wooden crating) was occasionally challenged and subsequently determined to be performed by other types of specialized craft labor such as teamsters, pipe fitters, and carpenters.

Analysis

Given the number of unknowns associated with this demolition project, the need for specialized craft workers was mostly related to emergent work (i.e., new, troubleshooting, quick-response work with little advanced warning of need). Since these types of craft workers reported to a centralized maintenance organization primarily geared for routine maintenance for many of Hanford's operating facilities, its resource base is managed as a resources pool. The number of resources for a given type of craft within the labor pool is primarily based on long-term work load projections from the operating facilities. Although this centralized support organization did its best to support the project's emergent needs (even sometimes at the expense of other Fluor Hanford projects), eventually it was necessary to establish special priority for the 233-S Facility Deactivation Project scope.

This situation was exacerbated by the unseasonably early and extreme winter weather conditions in late 2003. The extremely cold weather increased the need for electrical power, installation of additional heating and freezing protection, and troubleshooting of equipment. Shortages of specialized craft labor were mostly for electricians and teamsters. Consequently, project management negotiated a special acquisition of resources and a company-level priority for the 233-S Facility Demolition Project. This action resulted in a much greater efficiency when dealing with emergent issues.

Considerations for Future Projects

- Davis-Bacon Act reviews should be performed early in the planning stages to ensure the right crafts are aligned with the project.
- When obtaining commitments for specific craft resources, up-front discussions and agreements should be established to ensure availability of such resources during the routine activities. A priority for obtaining additional resources during unplanned/emergent conditions should also be established and well understood among participating organizations.

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DEMOLITION APPROACH AND EQUIPMENT
MARTIN® FOG CANNON™

"Misting devices effectively controlled airborne dust and alpha contamination."

Situation

The potential for dispersion of very high levels of alpha-contaminated dust particulates (measured in millions of disentgrations/minute/100 cm^2) during the concrete shearing and debris loading processes was a major concern for the 233-S Facility Demolition Project. Any contamination dispersion beyond a pre-established 40-meter contamination control area boundary was not acceptable.

The MARTIN® FOG CANNON™ (lower left) controlled dust and contamination during the concrete shearing of the 233-S Facility.

Analysis

The MARTIN^R FOG CANNON™ (hereafter termed fog cannon) was used to control contamination/dust dispersion during the aggressive demolition activities involving the concrete shear. Depending on the wind direction and velocity, one or two fog cannons were aimed at the demolition area. One of the two cannons was trailer-mounted (heavy-duty car trailer) with its own 480-volt electric generator. This was somewhat cumbersome, but the configuration made it easy to move when necessary to accommodate changes in wind direction. The second cannon was skid-mounted and required a fork lift to reposition it when the wind shifted. Due to project safety rules, any time the skid-mounted unit was moved, the 480-volt electric power was required to be disconnected which required two electricians to be available at all times.

Both fog cannons required an external source of water which was supplied by a fire hydrant near the 233-S Facility. Each cannon also had a reservoir for additives that could be blended in with the water and dispersed. The additive selected for 233-S was Polo Dustcon (a surfactant used to reduce surface tension of the water droplet and produce an even finer droplet size). Due to infrequent use of the additive system and the success without using the surfactant, this may not have been necessary. (Note: the Polo Dustcon product was used later during the decontamination efforts and seemed to assist in the removal of contamination.)

The fog cannons delivered a very fine droplet and produced a fog over the area being sheared. The only drawback to the fine droplet size was that the droplets were easily affected by wind speed and direction. On a windy day with variable directions, the cannons required frequent redirection. Any breeze from the side or head-on reduced the fog cannon's effectiveness.

Considerations for Future Projects

- The MARTIN® FOG CANNON™ delivered a fog which "blanketed" the demolition area. These units effectively met the dust/contamination control requirement.
- The MARTIN® FOG CANNON™ systems were manufactured in Italy and required some electrical rework upon receipt at the Hanford Site. The system was not originally UL listed or certified by any nationally recognized testing laboratory; however, certification was eventually received from the Hanford Site NEC inspector after all repairs and modifications were made.
- The ability to blend a surfactant with the water supplied to the fog cannon proved to be unnecessary. If an additive is needed, a simpler eductor system could be added to the water supply line to inject an additive with no moving parts or electrical control system.
- The MARTIN® FOG CANNON™ can be purchased from Martin Engineering, of Neponset, Illinois.
- A fog cannon mounted on a much smaller four-wheeled cart (e.g., 4 ft x 6 ft) using high flotation tires might offer improved versatility.

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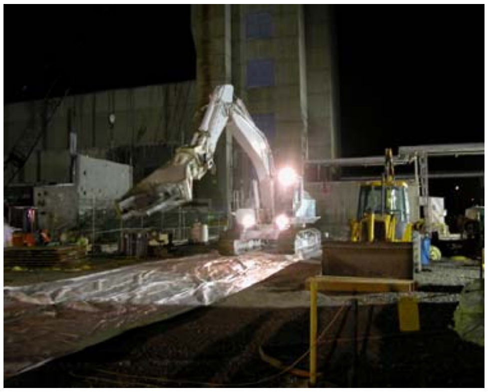
DEMOLITION APPROACH AND EQUIPMENT
Front-End Loader vs. Excavator Bucket

"Use of a front-end-loader/backhoe eliminated the need for frequent change-outs of the shear/bucket attachments on the excavator."

Situation

During initial phases of 233-S Facility demolition planning, attempts were made to minimize the amount of heavy equipment needed to perform the demolition. This approach assumed that by dedicating a given piece equipment for multiple tasks there would be less machinery to potentially contaminate and possibly have to purchase. The physically constricted working conditions also influenced the basis for trying to reduce the amount of equipment within the demolition zone. Once equipment was placed within the zone, it would need to stay there for the duration because of the challenges and time involved with decontamination efforts to get the equipment out.



Front-end loader bucket (right) was found to be more efficient for loading of demolition debris than to repeatedly switch-out the excavator's shear attachment (left) with a bucket.

The excavator utilized on this project was supplied by a subcontractor and came with a shear and a bucket attachment. In the early planning activities, the subcontractor suggested that switching from one attachment to the other could be done quickly and easily, thus reducing the equipment required for the project. It was also believed that use of an excavator's bucket would generate less airborne dust than a front-end loader.

Analysis

In the early days of 233-S Facility demolition, it became obvious that only a few hours of shear operating time would produce enough rubble to load for a given day. The need to change the excavator's attachments on a near-daily basis became very time consuming. It took almost half of a shift to change attachments (when allowing for the dress/undress time and the time necessary to move the excavator from the demolition site to a staging area for performing the attachment change). Also, an additional set of crafts were required to be available to perform the shear/bucket swap. While the swap was in progress, the lost production time of half a shift for an entire crew (i.e., D&D workers, the shear operator, and radiological control technicians) made it mandatory to find an alternative to the excavator bucket for loading the demolition debris.

A front-end-loader/backhoe (John Deere Model 510) was located on the Hanford Site, and was transferred into the demolition area to perform the debris removal. The John Deere equipment performed an excellent job of removing the debris and was found to be much more efficient than the excavator for loading the waste containers. Also, because it was more maneuverable than the excavator, it was better able to deposit debris into the waste containers without spilling material on the ground adjacent to the container. Use of the front-end loader bucket did not generate additional contamination control concerns.

Considerations for Future Projects

- Changing attachments (e.g., shear to bucket, or vice versa) on heavy equipment is more challenging in contamination areas, as compared to working on equipment in a non-contaminated shop setting.
- The different labor resources that may be required for the equipment change-out could result in additional labor costs, as the core work group is temporarily placed in a stand-by mode.
- Front-end loader/backhoe equipment is commonly used and readily available at most DOE sites. Use of an on-site and highly-skilled operator can help to match the demolition rate of the excavator.
- No problems were experienced with the backhoe/front-end-loader used on the 233-S Project, likely because of a good preventive maintenance history. A thorough inspection prior to placing equipment into a contamination area is beneficial and results in less down time.
- Foam-filled tires should be installed prior to sending any rubber tire equipment into the zone. This issue was known when the front-end-loader was sent into the contamination area and foam-filled tires were ordered. When the inevitable puncture did occur, the foam-filled tires were available and all four tires were changed at that time.
- The backhoe attachment was not used on this project. It would have been prudent to remove the backhoe attachment prior to sending the front-end loader into the zone as it would have made the tractor even more maneuverable.
- The excavator and/or front-end loader work zone can prevent other D&D activities from being concurrently performed.

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DEMOLITION APPROACH AND EQUIPMENT
Mockups / Training

"Mockups served well for worker training and equipment acceptance."

Situation

The 233-S Facility Demolition Project was a first-of-a-kind effort that utilized a variety of commercially available (but specialized) equipment. This project also employed a number of unique processes for waste materials handling, packaging, and transportation. To ensure that the appropriate workers and supervisory staff were sufficiently trained and qualified on the right equipment, mockups were staged in cold (i.e., non-contaminated) settings before the equipment was actually used on the highly contaminated buildings.

Analysis

Given the varied levels of experience among the D&D workers at the front end of the project and the risks associated with this highly-contaminated facility, the use of mockups proved to be extremely beneficial. Training was needed to ensure that an adequate number of workers could proficiently install, operate, and care for a variety of concrete tools and ancillary equipment (e.g., portable concrete core drills, power-actuated fasteners, diamond-blade concrete saws, saw shrouds, etc.). Training was provided by the equipment's manufacturer, instructors from the concrete services industry, and/or in-house field supervision. Workers not only gained proficiency with the equipment, but were also able to identify opportunities for accepting and/or improving the hardware and processes. Stackable concrete blocks (approximately 6 ft L x 2 ft W x 2 ft H) were purchased at a very low cost from a local concrete supplier to serve as a mockup of a 233-S process hood wall. These blocks were easily positioned via a forklift or crane and served as a simulated wall of the 233-S Building process hood.

Mockups were also very helpful for fine tuning various waste-handling processes. For example, a full-sized mockup of the largest concrete slab section to be removed from the process hood was built out of wood. Protrusions were even added to simulate an I-beam and monorail that would be encountered with one of the process-hood roof slabs. Workers practiced the different wrapping and handling methods on the mockup slab in a clean area. The proficiencies gained during the mockup training helped to reduce time and exposure the workers experienced in the contamination area. To support waste transportation requirements, the wooden slab was also used to simulate the loading of an actual concrete slab onto a flatbed trailer and to practice securing a concrete slab with tie-down chains.

In one instance, however, a mockup demonstration was not fully successful. Prior to use of a hydro-laser (i.e., ultra-high pressure water washing) system for decontaminating the wall and floor surfaces of the process hood, the associated equipment and process was demonstrated on a clean, painted, unobstructed, and flat exterior wall of the 233-S Building. While this “cold” demonstration appeared to be successful, it did not accurately represent a number of the challenges that were present within the process hood. For water collection and contamination control purposes, the hydro-laser system utilized a vacuum shroud that surrounded the water jet applicator; efficiency of this vacuum/water collection system was based on the ability to maintain a continuous contact and seal with the surface being cleaned. Due to the irregular surfaces, protrusions, and various layers of materials that were actually adhered to the process hood’s interior surfaces, a number of challenges were encountered (e.g., clogging of vacuum lines, ineffective seals, and errant water spray). Actual performance within the process hood might have been better if the mockup testing for the hydro-laser system would have more closely simulated actual and/or worst-case conditions.

Considerations for Future Projects

- Investments in training with full-scale mockups can pay large dividends in the areas of worker involvement, useful feedback, proficiency, risk exposure, and safety improvement.
- Mockups can help minimize unnecessary conservatism and excessive controls that might otherwise be imposed due to unfamiliarity and uncertainty.
- Effective use of mockups can result in higher-quality work packages and reduce in-field performance issues.
- In some cases, mockups should accurately reflect actual and/or worst-possible case conditions.

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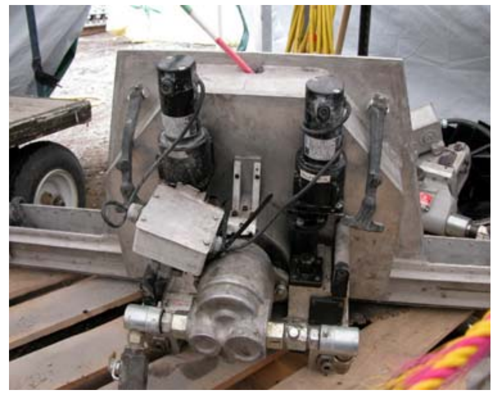
DEMOLITION APPROACH AND EQUIPMENT
Concrete Wall Sawing

"Concrete wall saws were effective, but improvements should be considered."

Situation

After the less-contaminated portions of the 233-S Facility were demolished via an excavator and concrete shear, the second phase of demolition involved a completely different approach. This second phase involved dissecting the highly contaminated 233-S Building process hood (a 15 ft wide x 32 ft long x 33 ft high, reinforced concrete structure with 12-inch thick walls) by cutting and removing blocks of concrete with dimensions of up to 8 ft x 15 ft per block. To complete this task, over 900 lineal feet of concrete cutting was necessary to remove a total of 34 blocks. This phase of work was performed in cold weather (starting in January 2004), and the high levels of fixed contamination required workers to wear multiple layers of protective clothing, hoods or face masks, and Power Air Purifying Respirators (PAPRs). A contamination area (CA) boundary was established at a 40-meter radius from the center of the process hood.



Close-up view of concrete wall saw showing electric drive motor (left) and the electric plunge depth motor (right). While cutting 233-S process hood structure, several modifications were necessary to optimize saw system performance.

During actual cutting operations, movement of the saw was accomplished via a pendent controller. Rotation of the saw blade was accomplished via an hydraulic power unit, which was positioned outside of the CA boundary; hydraulic hoses transferred power to the saw. Saw travel along its guide track and saw depth/plunge were driven by separate electrical motors that were housed on the saw (as shown in the graphic).

Analysis

While the 233-S process hood was successfully disassembled via saw cutting, a number of factors did impact field operations. Cutting was initiated in early winter and required special attention to the freezing of saw cooling/lubrication, water, and the warming of hydraulic oil. A shroud was specially designed to control the contaminated water misting from the rotating saw blade; the shroud effectively controlled the misting, but added significant weight to the saw and increased load/wear on the electric-drive motors. The hydraulic power unit ended-up being located further away from the saw than was originally planned; efficiency of power transmission was reduced with the increased length of hydraulic hose. Various components of the saw system also required some reconfiguration in order to fully meet Hanford Site requirements (including Occupational Safety and Health Administration [OSHA] and National Electric Code [NEC] requirements). Use of scissor man-lifts (rather than scaffolding) worked very well for supporting the saw track and saw installation/removal. The least reliable components on the saw system were the electric-drive motors that provided saw travel and saw blade depth/plunge.

Considerations for Future Projects

- While much less destructive than other demolition techniques, concrete cutting is a messy job (i.e., water mists, concrete slurry, hoses, and wires, etc.) and requires attention to detail.
- Future projects should evaluate the possibility of using saws that could operate on only one type of service (i.e., all electric or all hydraulic). Combining the two power types on a saw requires more controls could create more opportunity for lower reliability.
- Modifications to commercially-available equipment should be avoided when possible.
- When the custom shroud was added to the saw, it appeared to cause some operational problems with the saw motors due to the added weight.
- When using hydraulics, the hydraulic power unit should be positioned as close to the saws as possible in order to maximize efficiency of power transfer. For the 233-S Project, the hydraulic power units were located over 100 feet from the sawing (outside of the CA boundary). While efficiencies were lost, benefits were realized in maintenance and operation of the hydraulic power packs.
- Special heating of hydraulic oil reservoirs and pre-operational circulation of the hydraulic fluids are necessary if operating with long hoses during cold winter months.
- During the subfreezing conditions, water lines should be drained at the end of the day and the saw stored in a heated area when not in use. A water/glycol mixture could be used an alternate method to prevent freezing of water lines.
- All electrically powered and/or controlled equipment should be evaluated and individually inspected to ensure compliance with project site requirements (e.g., local procedures, NEC, OSHA, etc.).

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DEMOLITION APPROACH AND EQUIPMENT
Subcontracting Concrete Wall Sawing Services

"Subcontracting of concrete saw-cutting services was a prudent business approach."

Situation

The demolition approach that was approved for the 233-S Facility involved use of an excavator and concrete shears to size reduce the less-contaminated structures (i.e., mobile office MO-317, 233-SA, stairwell and single-story portions of the 233-S Building). Also, due to the much higher levels of alpha contamination within the 233-S process hood, a less-destructive demolition technique (i.e., concrete wall sawing) was selected for this structure in order to support certain radiological control requirements.

Concrete wall saw (upper left) positioned to begin a horizontal cut just below the roof line of the 233-S process hood. Subcontracting (rather than self-performing) of non-routine and specialized services can be effective.

Concrete wall sawing was not new to Hanford, but had been performed on an infrequent basis -- typically to create new or enlarged openings (e.g., doors or windows) in radiological and non-radiological buildings. Since concrete wall sawing requires specialized equipment and operators, it can be viewed as somewhat of an "art" that improves with experience. Prior to the start of this project, Hanford's labor forces did not possess the equipment or necessary skills to perform cutting of the 233-S Building's process hood (a 15 ft x 32 ft x 33 ft tall, reinforced concrete structure with 12-inch thick walls).

Analysis

The decision to subcontract the saw-cutting services proved to be beneficial. If the project had significantly more time for planning and preparations and if Hanford had a nearly continuous "feed stream" of future concrete-sawing needs, equipment could have been purchased and a substantial training program could have been implemented. However, given the aggressive schedule associated with this project and the uncertainty associated with specific concrete saw cutting needs over the next five years, subcontracting of these unique services was a practical approach.

It should be noted that the project did purchase the concrete-cutting saws since it was acknowledged that the saw would get contaminated and would not be able to be released back to the subcontractor. The hydraulic power units (used to power the rotation of the saw blades) were leased because they were staged outside of the contamination area and did not come into contact with any contamination.

Considerations for Future Projects

- If specialized services are required that a project does not possess and might not need in the near future, then subcontracting may prove to be a prudent approach.
- Subcontracting of technical services at Hanford requires an understanding of the Site labor contract and negotiation with the respective labor forces may be necessary.
- When reviewing a potential saw-cutting contractor's records of experience, the amount of experience in nuclear applications should be well understood where it is important to the job under consideration. Nuclear applications have special requirements (e.g., in areas of contamination control and personnel protection) and could present significant challenges to a subcontractor not experienced in nuclear applications. The subcontractor utilized on this project was sufficiently qualified.
- When evaluating trade-offs between leasing saw equipment from a subcontractor versus having the project purchase the equipment, factors such as project duration, contamination possibility, and lease rates (including stand-by rates) should weigh into the final decisions.
- Equipment specifications and performance requirements (e.g., National Electric Code and Occupational Safety and Health Administration) should be clearly understood and noted in contracts. Some saw-cutting systems/components, as used in the commercial sector, are custom made and may not carry such approvals/listings.

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DEMOLITION APPROACH AND EQUIPMENT
Shrouds for Concrete Wall Saw

"Saw shrouds effectively captured the contaminated mist, but added load to the saw track motors."

Situation

Demolition of the 233-S process hood (a 30'L x 15'W x 33' H structure comprised of 12-inch-thick reinforced concrete walls) was accomplished by cutting the building into large rectangular blocks weighing up to eight tons. After cutting each block, it was then lowered to the ground via crane for waste packaging and disposal. The block cutting was accomplished via large (42-inch diameter), track-mounted, diamond-blade wall saws.

Close-up view of the saw shrouds that were designed, fabricated, and deployed for all concrete cutting on the Process Hood. The fixed receiver shroud (lower left) "accepts" the rotating blade at building corners and wall ends; the primary saw shroud (right center) fits over the traveling blade and motor assembly.

Prior to initiating a cut, the saw's guide rail was mounted on the building exterior (roof or wall) along a predetermined cut line. After mounting the saw to the guide rail, the saw would typically make four passes (advancing depth 2-4 inches each pass) to completely cut through a 12-inch-thick roof or wall section. During the cutting processes, 4-7 gallons of water were applied to the saw blade each minute to support blade cooling and the removal of concrete fines/slurry from the saw kerf.

Even though most of the plutonium contamination was fixed to the interior wall surfaces, contamination was presumed to also exist within the pores of the concrete walls. For contamination control purposes, special efforts were made to eliminate all potentially-contaminated misting that could be released from the saw cutting process; gutters were installed over the interior wall side of the cut lines, and a specialized saw shroud was used to control misting to the outside environment. Most commercially available concrete saws are typically equipped with some form of open-sided shroud (typically, a fender with "mud flap" device) to minimize flying debris, but are not equipped to minimize the migration of misting that is discharged via centrifugal force of the rotating saw blade.

Performance specifications for the saw shroud system included the ability to capture all water spray from the exterior of the process hood, capture nearly all dripping water from the saw kerf, allow for remote flushing of the saw blade and shroud interior, allow for gravity draining and vacuum-assisted removal of water from the shroud interior, and to accommodate the various roof and wall cutting orientations. The shroud system was also to be constructed and be light enough to be installed/removed by no more than two field workers. As depicted above, the resulting system was primarily comprised of (1) a receiver shroud that attaches to the cantilevered-end of the saw track saw and accepts the saw blade as it passes beyond the end of a wall section or a building corner, and (2) the primary shroud that attaches over (and travels with) the saw blade.

Analysis

The shroud design proved to be very effective at eliminating the potential for the spraying of mist during cutting and greatly minimized the release dripping of water from the saw region. The system was well designed for gravity draining, and included ports for hose connections for purposes of containment.

While the system was light enough to be routinely installed/removed by two field workers (i.e., the receiver shroud weighing 27 pounds, and each component of the primary shroud weighing less than 60 pounds, the standard motors on the track drive system did experience overloading conditions and failures due to the additional weight of the primary shroud. (Note: The rotation of the saw blades are hydraulically driven, while travel of saw along the guide-rail is driven via direct current [DC] electrical motors.) This issue was partially rectified by upgrading the baseline/stock motors from 24V-DC to a 90V-DC motor.

Considerations for Future Projects

- The design of the innovative shroud system used on this project should be viewed as very effective at controlling the release of potentially contaminated mist, and may also prove to be effective for other projects with similar objectives. However, capabilities of the electric drive motors used for saw travel along the guide track should always be evaluated with respect to the additional weight resulting from use of a non-standard shroud, or other system accessories.
- If spent saw water/slurry is drained from the saw shroud via hose, the additional weight of the drain hose may be proportionate to the length of the hose above grade level. Various tether-management techniques can be employed to minimize any loading caused by a drain hose.
- Further review of the shroud system, including materials of construction (e.g., a material other than aluminum), could result in opportunities for reducing weight of its subcomponents.

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PLANNING AND SCHEDULING
Work Schedule Changes and Optimization

"Special work shifts helped to optimize field performance."

Situation

Deviations from the Hanford Site's standard working hours were implemented on the 233-S Facility Demolition Project in order to accommodate changes in seasonal weather patterns and to optimize the performance of interdependent field tasks.

Small teams were occasionally assigned to begin their work shift several hours ahead of most workers. This practice helped to minimize start-up delays near the front-end of the primary shift by ensuring that monitoring instruments, tools, and equipment would be ready and staged for use.

To take advantage of early daylight hours and to help minimize the potential for heat stress on field workers during the summer of 2003, standard work shifts began at 6 a.m. Later, based on modeling of historical meteorological data and predictions of daily wind levels during the fall of 2003, a second work shift was established for work during a modified graveyard shift from 10 p.m. to 6 a.m. During the daytime, wind conditions became less severe and the unseasonably cold weather increased the challenges of working/operating in subfreezing conditions; consequently, the graveyard shift was eliminated.

Special work schedules were also created for two Radiation Control Technician (RCTs). These RCTs reported to work two hours prior to the normal day shift to perform the daily routines (e.g., radiation instrument sources checks, environmental monitor checks, and radiological surveys of the designated contamination areas). After experiencing delayed starts during the first several days of extremely low temperatures, additional personnel were added to the early-start work shift to remove equipment from heated storage, position hoses for connections, start-up/warm-up equipment, etc.

Another change that resulted in schedule improvements involved the rate at which workers would need to use Hanford's access-controlled entry (ACE) process for work in contamination areas. Workers initially needed to review, acknowledge, and sign a radiation work permit (RWP) on a daily basis. Since the project eventually evolved to operating under a single RWP, (rather than multiple RWPs), ACE processing was able to be reduced from a daily task to weekly task.

Analysis

Based on management approval, the establishment of alternative/non-standard work schedules is an option for Fluor Hanford projects. This option helped to minimize (and in some cases, eliminate) routine delays during daily activities.

Considerations for Future Projects

- Scheduling of open-air demolition should be routinely evaluated to take full advantage of seasonal and near-term weather conditions
- A thorough breakdown and evaluation of field work subtasks (e.g., nightly storage of saw-cutting equipment pre-staging, utilities hook-up, etc.) can help identify opportunities to optimize scheduling of routine task.
- Project plans and schedules should include specialized training and/or qualification to maximize worker availability.
- Strategic placement of tools and equipment and the movement of personnel should be well "choreographed" in order to realize efficiencies.
- Minimizing the number of RWPs can help to ease a transition from ACEing in on a daily basis to ACEing-in on a weekly basis.

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PLANNING AND SCHEDULING
Weather-Based Impacts to Project Schedule

"Severe weather conditions impacted open-air demolition activities."

Situation

The 233-S Facility Demolition Project experienced record-setting weather conditions for winds, low temperatures, snow depth, and snow duration.

Based on review of historical weather data, weather conditions (e.g., winds, snow, and subfreezing temperatures) during demolition of the 233-S Facility were much more severe than normal.

To prepare for open-air demolition activities during the fall and winter months, the project evaluated historical weather data for the Hanford Site. These weather data indicated that (based on a 12-miles-per-hour wind speed limit established as a control in the project's Radiological Safety Plan to minimize the risk of contamination spread), the project would likely experience wind-related work restrictions during about 10 percent of the project's period.

Analysis

The fall of 2003 and winter of 2003/2004 proved to be an exception to the average weather patterns at the Hanford Site as some weather conditions had not been experienced since 1946. Winds (very common to the Hanford Site) gusted in excess of 50 miles per hour. Snow reached depths unseen on the Site in the past 10 years and subfreezing temperatures depths continued for abnormally long periods. During November 2003, the actual down-time as a result of extreme weather conditions was measured at 37 percent. This same level of weather-based impact held true through the winter months and into the early months of spring.

The greatest weather-related threat to the project's schedule was the wind. As noted above, demolition activities were restricted to wind conditions at 12 miles per hour or slower. In addition to the wind speed restriction for radiological control purposes, it was found that wind speeds near 12 miles per hour would create industrial safety hazards for workers handling materials with large surface area (e.g., the various forms of plastic sheeting used for contamination control and lining/wrapping of waste materials). Wind speeds near the 12-miles-per-hour limit also impacted the performance of the water-fogging machines that were used for dust suppression and contamination control during the concrete-shearing activities. Regardless of ambient temperature, high winds can occur at Hanford during any month. In one instance, high wind conditions overturned a temporary structure that was insufficiently anchored.

Since water was extensively used throughout the project for purposes of contamination control and dust suppression, a freeze protection program was implemented. Water lines were protected with heat tracing, while certain hoses and equipment were set up and removed from the outdoors each day to prevent freezing. However, the extreme cold would occasionally find that one remote fitting or valve that was inadequately heat traced for temperature as low as minus 20 degrees Fahrenheit.

Finally, freezing rain, which is common for winter months on the Hanford Site, occasionally formed continuous sheets of ice, created slipping hazards, and impacted the pace of personnel and equipment movement. The abnormally deep snowfalls also slowed movement and created new hazards by hiding what might normally be visible.

Considerations for Future Projects

- Historical weather data should be used when establishing baseline schedules for open-air demolition activities; actual conditions can be more favorable or less favorable. This particular project experienced 24 weather-based delays from November 2003 to April 2004.
- Project planning should consider all factors of weather and plan for the worst-case conditions.
- Short stay times will result in higher personnel protective equipment (PPE) consumption rates, especially during periods of high temperatures. See other fact sheet for further discussion on heat-related weather impacts.
- Foul-weather procedures (e.g., cold temperatures and high winds) should be developed in advance of demolition start up and include actions such as heat trace verification, draining of hoses, removal of tents, etc.
- Alternative work activities (i.e., scope other than in-field demolition) should be planned and ready to work in order to take full advantage of those days when extreme weather prevents demolition work from taking place.
- Appropriate type and quantity of PPE (e.g., sunglasses, sun screen, cool suits, insulated boots, gloves, coveralls, hats, ice cleats, etc.) should be purchased for work in extreme conditions.
- Safety and comfort of the workers during all temperature and weather conditions need to be considered in order to maximize productivity. For example, warming huts, space heaters, shade canopies with picnic tables and benches were used during the project. Also, bottled fluids (e.g., water and assorted sports drinks) were available at appropriate locations.

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SITE PREPARATION AND INFRASTRUCTURE
Electrical Power Supply

"Electrical power needs were underestimated."

Situation

Equipment on the 233-S Facility Demolition Project required numerous 120, 240, and 480 volt (V) AC receptacles. The most common hand tools (e.g., bandsaws, reciprocating saws and small drills) ran on 120-volt power. Larger equipment such as high-efficiency particulate air (HEPA) vacuums and concrete coring drills required 240-volt power. The hydraulic pumping units for the concrete wall saws and the skid-mounted MARTIN® FOG CANNON™ required 480-volt power.

In addition to the D&D tools noted above, additional power outlets were required to support radiation monitoring instrumentation, heat trace for freeze protection, water filtration skid pumps, and temporary space heaters.

Temporary electrical power panels were erected and installed to support demolition equipment. The need for additional panels increased as the project entered the colder-than-normal winter months of 2003/2004.

Analysis

Based on a projection of electrical equipment use, temporary electrical panels were erected to supply power to the demolition project. The panels were located outside the contamination area to allow for ease of maintenance. This plan initially worked well, but it became apparent that additional receptacles would have been beneficial as additional needs were identified.

The additional power demands to support cold weather operations was compounded by the shortage of outlets, and required unplugging of freeze-protection devices during the warm day-time activities and plugging it back-in during the late afternoon hours. If a freeze protection circuit was left unplugged over night, the component would likely be frozen the next morning, thus impacting startup of D&D activities for the day.

Relocating 480-volt equipment required electricians to de-energize the equipment and unplug it prior to moving it. On a couple of occasions, it was necessary to perform maintenance on the 480-volt receptacle. This maintenance required taking out power to the entire temporary power panel, affecting other activities using the panel.

Considerations for Future Projects

- Each 480-volt circuit should be fed via an individually lockable disconnect switch, which feeds to a motor contactor, and then feeds a 480-volt receptacle. This configuration will allow the D&D worker to turn receptacles on and off without the need for electrician support.
- All 480-volt outlets should be connected to provide the same phase rotation, and all 480-volt equipment should be wired and tested so it will work on any of the 480-volt receptacles.
- All low voltage outlets should be protected with a ground fault circuit indicator and rated for outdoor use.
- Identical, multiple panels should be constructed with enough outlets on each panel to provide all the projected loads required for the project. Provisions for at least three panels should be made, with additional panels being desirable.
- Strategically locating the panels around the project site (rather than at one centralized location) will help to ensure the availability and accessibility to adequate power supplies. Smart locations also allow for shorter extension cords, thus reducing voltage drops and tripping hazards.
- The 480-volt equipment should not be hardwired, as the need to relocate a piece of equipment may occur as soon as it is hardwired. This approach also makes it easier to remove equipment from a given area for repairs, and for demobilization at the end of the project.
- There can never be too many extension cords. For the 233-S Project, 1000-foot spools were purchased, and cords were fabricated to provide the needed lengths in specific wire gauges designed to minimize voltage drop.
- Protection of electrical power cords from damage due to vehicle traffic is essential on a demolition site. Initial project estimates for cord protectors should be multiplied by a factor of three or four.
- Electrical equipment should meet all National Electric Code (NEC) requirements and have a label/listing certifying that it has been inspected by a nationally-recognized testing laboratory (e.g., Underwriters Laboratory or UL).

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SITE PREPARATION AND INFRASTRUCTURE
Materials Control

"Materials control infrastructure (e.g., purchasing, inventory, and storage) was underestimated."

Situation

During the pre-demolition phase of the 233-S Facility Demolition Project, portions of the 233-S Building were effectively used for storing supplies and equipment and to provide rooms for changing in and out of personal protective equipment. However, as the project transitioned from a demolition-preparation phase to a demolition-ready phase, the 233-S Building was no longer available for such purposes.

A number of transport containers were used for temporary storage of demolition supplies and equipment. The project's needs for purchasing, inventory, and storage of materials were greater than originally planned.

Many supplies, materials and types of equipment (different from those required for pre-demolition operations) were needed to support the demolition phase of the project. Many of these items were needed on an expedited fashion to support emergent issues, and required storage at the demolition site for ease of access and continuity of operations. Consequently, 12 transport containers were acquired and staged outside of the demolition zone to house the equipment, supplies, and materials. One staff member was originally assigned the lead responsibilities for keeping track of all project materials and equipment; this proved to be insufficient.

Analysis

Overall, the needs to support the purchase, receipt/inventory and storage of supplies, and equipment were underestimated. The demand for supporting these activities increased (from what was originally planned and staffed as a one-person job) to at least a two-person task; one person to order/procure and one person to track item locations and monitor usage.

The use of transport containers for storage of supplies and equipment was adequate for protection from weather elements (excluding temperature), but marginally acceptable for ease of managing inventory. The necessary systems for ensuring that sufficient quantities of consumables would be available when needed were not fully developed at the front-end of the project; at times, shortages were experienced for plastic raingear and other protective clothing, selected tools, and materials/supplies for establishing temporary power distribution systems. These deficiencies were mitigated as the project evolved.

Considerations for Future Projects

- Alternate capability for the support services located in the building being demolished should be thoroughly evaluated during the early phases of demolition planning and site layout; facilities to be demolished are often used for personal protective equipment change locations, shelter from weather, storage of materials, maintenance shops, and office space, but will only be available prior to the start of demolition.
- The rigor necessary for materials ordering/receipt, storage and inventory during the demolition phase of the project will likely be much greater than experienced during the operations or demolition-preparation phases of the project. Outdoor operations will require additional supplies/materials such as plastic tarps/sheeting, foul weather gear, heat tape, power cord protectors, lights, etc.
- Materials management personnel and related controls should be established sufficiently early in the project life-cycle.

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RADIOLOGICAL CONTROLS
Soil-Sement™ and PBS™ Fixatives

"Soil-Sement Solutions and PBS Fixative effectively locked down particulates."

Situation

The interior surfaces of the 233-S Facility were known to be highly contaminated. In some areas of the 233-S process hood, the activity levels exceeded 10^9 disintegrations/minute per 100 square centimeters. Of major concern during project planning was the need to identify methods to control the dispersion of contaminated materials outside of the 40-meter contamination area boundary. The field operations tasks with the greatest potential for releasing contamination were, in order of severity: (1) mechanical shearing of 233-SA/233-S structures; (2) load-out of demolition debris into the Environmental Restoration Disposal Facility (ERDF) cans; and (3) sawing the process hood walls into slabs, and associated waste load-out of the slabs.

D&D worker applying Soil-Sement™ and water mixture to debris pile via portable pump, hose, and nozzle to effectively "lock-down" particulates.

In addition to misting/fogging with water (covered in a separate Fact Sheet), the use of fixatives is a proven technique to minimize the potential for contamination dispersion. Several types of fixatives were reviewed, and two were selected for use on the 233-S Demolition Project.

Polymeric Barrier System™ -- The Polymeric Barrier System™ (PBS) is essentially a high-grade acrylic polymer similar to latex paint. It was chosen for use because, compared to other fixatives, it is inexpensive, easily applied (i.e., via brushes, rollers, airless sprayers, etc.), and is non-toxic during application. This product is widely used at projects across the Hanford Site, which offered a good experience-base for its use. The PBS was applied to all interior surfaces of the 233-S Facility prior to the onset of demolition activities, and as needed during the demolition project. For large area applications, airless sprayers were used to minimize disrupting surface contamination.

Soil-Sement™ -- Soil-Sement™ is an aqueous, acrylic-vinyl-acetate emulsion which polymerizes on contact with air. It is designed for the dust and erosion control and soil stabilization. It was used on the 233-S Project to prevent the re-suspension of contaminated materials in debris piles and other surfaces of the building where the PBS was disturbed. For general contamination control, a PRO/pak® sprayer, made for foam fire suppression, provided a quick and effective application. This portable sprayer has a 2.5-gallon concentrate tank and connects to a water supply with a 1.5-inch diameter hose. The standard discharge hose of a couple feet can be replaced with an optional 25-foot hose if the workers do not want to carry the pack on their shoulders. Soil-Sement™ was placed into the concentrate tank and the sprayer set to blend the concentrate via an eductor, at the maximum rate of 6 percent. This ratio provided an adequate crust to hold the contamination and dust as long as it was not disturbed. Foot traffic and equipment movement would break the crust and expose the contamination. Because the demolition involved the use of water generating equipment during the demolition, it was desirable to have the ground absorb runoff rather than to collect the water. The thin coating of Soil-Sement™ allowed the water to dissipate to the ground.

Solutions up to 25 percent concentration (v/v) Soil-Sement™ were applied to larger areas using a 1.5-inch diameter fire hose and fire-spray nozzle. These higher concentrations were used where extremely high levels of contamination were present, or before high wind conditions were anticipated. The Soil-Sement™ was mixed in a heated, 250-gallon tank for batch mixing, and delivered by a gasoline-driven pump. The product was applied in a layering effect to rubble piles as they were created. This approach was taken to ensure that the Soil-Sement™ was evenly distributed throughout the waste and would be effective during the waste-loading process. The product was also applied to other areas of concern at the end of each work shift, and as needed throughout each shift.

Analysis

The project was unable to locate reliable estimates for the effectiveness of these fixatives. One analysis indicated that no more than 20 percent should be assumed for input into the atmospheric dispersion model. However, this was deemed to be overly conservative based on observations during use on other projects. Both PBS™ and Soil-Sement™ met or exceeded project expectations during demolition of 233-S when used within the constraints identified by their respective manufacturers.

PBS™ is limited to use at temperatures above 50 degrees Fahrenheit since it will not cure below that level. In addition, some minimal flaking was observed during demolition of certain areas. It is believed, however, that the flaking resulted from the failure of other surface materials to which the PBS™ was adhered.

Soil-Sement™ performed as specified on soil/rubble piles (if left undisturbed). Moving of equipment personnel or other mechanical activities over the area reduced its effectiveness and required reapplication. During periods of cold weather (when PBS™ would not cure), Soil-Sement™ was used to control contamination spread from concrete walls of the process hood. The product performed acceptably well for preventing contamination release from wind or weather.

Considerations for Future Projects

- PBS™, manufactured by Bartlett Services, Inc., performed well for containing the alpha contamination.
- While it appears that PBS™ adheres well to most materials, the effectiveness on previously painted or poorly prepared surfaces should be evaluated.
- PBS™ cannot be applied when it is cold; applications should be performed during warmer seasons or in heated buildings. Other fixative products should be evaluated for application at temperatures below 50 degrees Fahrenheit. PBS™ will become brittle in the cold; spraying

the product in/on flexible ventilation ducting is effective as long as the ducts are removed on warm days.

- Soil-Sement™ used in diluted solutions will not restrict the water absorption into the ground, while concentrated solutions will result in water runoff or ponding.
- The PRO/pak® sprayer, marketed by L.N. Curtis & Sons for fire suppression applications, was an effective system for applying low concentrations of Soil-Sement™. The maximum concentration available with this equipment is 6 percent, which was the ratio used at 233-S. Various nozzles are available depending on the needs of the user.
- PBS™ and Soil-Sement™ need to be stored in a heated location. Freezing temperatures will ruin the product.
- A heated (to prevent freezing) batch tank, of adequate size, should be selected to provide for multiple applications of Soil-Sement™; this allows for multiple applications of Soil-Sement™ between mixed batches.
- A small (5 horsepower) gasoline powered pump provides enough power for Soil-Sement™ coverage over large areas within in a few minutes. Spare pumps and manifold assemblies should be available on site in case of failure.
- If large amounts of low concentration Soil-Sement™ are desired and constant refilling of the PRO/pak® concentrate tank becomes time consuming, there are eductors available that adapt to the bung on a 55-gallon drum. Connecting a water supply line to the eductor will produce about 900 gallons of 6% solution. Eductors will not support the high concentrate solutions, so a batch mixing tank is still necessary if higher concentrations are needed.
- Common garden sprayers were also used to apply diluted PBS™ and Soil-Sement™. They are inexpensive and easy to use. The tips and wands plug over time because it is difficult to rinse them out in a high contamination area. Having replacement sprayers is mandatory. About 15-20 sprayers were utilized during the last nine months of the 233-S Facility Demolition Project.

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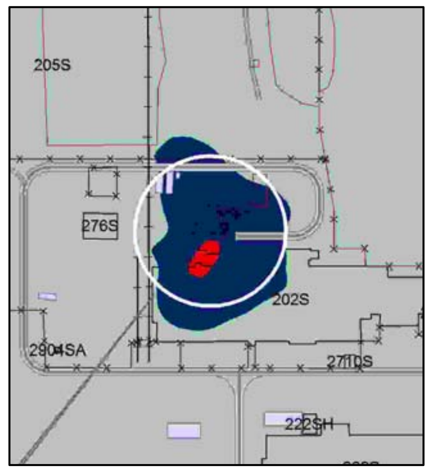
RADIOLOGICAL CONTROLS
Dispersion Modeling

"Radiological dispersion modeling confirmed a practical boundary for the contamination controlled area (CA)"

Situation

The 233-S Facility Demolition Project was the first open-air demolition of a highly-contaminated plutonium facility at the Hanford Site (and possibly within the DOE complex). For this reason, very little empirical information existed on the quantity of radioactive material that was likely to be released from various demolition activities. Information on the effectiveness of various release mitigation techniques was equally scarce. The 233-S Project turned to atmospheric dispersion modeling to provide information on the location and levels of radioactivity that potentially could be released. This data was also used to assist in the selection of specific demolition techniques.



Dispersion modeling confirmed that areas contaminated to >20d/m/100 cm^2 would lie within a 40-meter boundary, as measured from the center of the 233-S Facility

Initial calculations were performed using HotSpot 2.01™. Hotspot™ was developed for evaluating incidents involving radioactive material and is a first-order approximation of the radiation effects associated with the atmospheric release of radioactive materials. The code was developed at Lawrence Livermore National Laboratory for use in emergency planning and response. The General Ground Plume model provided by Hotspot™ is appropriate for use in calculating releases from demolition activities. Hanford Site averages for wind speed and stability class were employed for the model.

Upon review of the initial calculation results, it was discovered that the facilities surrounding 233-S had the potential of affecting dispersion patterns through various meteorological phenomena, including building wake effects. The calculations were rerun using ISC3®, a computer code approved by the U.S. Environmental Protection Agency. This code is more flexible than HotSpot™ and offers the following advantages:

- The calculated dispersion pattern considers building wake effects and other meteorological phenomena.
- The results are a more accurate estimate of potential radiation dose or contamination levels as opposed to worst case or maximum levels provided by HotSpot 2.01™.
- The ability to match the specific demolition steps (and associated release mechanisms) to historical meteorological data for the time period in which they are to occur allows for an accurate determination of contamination and radiation dose at specific locations.

The results from the ISC3® Prime calculations were used to determine that contamination is unlikely to be dispersed above the limits (20 disintegrations/minute per 100 square centimeters) established for the project contamination area (CA). This boundary was established at 40 meters from the center of the 233-S Facility.

Real-time modeling was performed during demolition activities to provide timely indication of significant deviations from the expected results. This required daily input from the project on activities that had been performed the previous shift, as well as expected activities for the upcoming shift. Off-site modelers were able to download meteorological data directly from a Hanford weather website that is managed by the Pacific Northwest National Laboratory. Each day, the 233-S Project received a dispersion map showing the predicted location and level of maximum radioactivity.

Analysis

Radiological surveys conducted during performance of demolition activities were not of sufficient sensitivity to strictly verify the accuracy of the model. However, the contamination levels detected were consistently below the established contamination limit. These results demonstrate the usefulness of modeling as a project planning tool and a method to lend confidence for the selection of specific demolition techniques.

Real-time modeling was of limited usefulness for the 233-S Demolition Project since conditions necessary to cause a significant increase in predicted contamination levels (e.g., high winds) almost always triggered a stop-work condition on the project's field activity.

Considerations for Future Projects

- Due to uncertainties surrounding parameters used for the modeling, the contamination limit established for the CA boundary was conservative. Future projects should use the regulatory values per 10 CFR 835 for total and removable contamination.
- Continue research on release parameters (e.g., damage ratios, release fractions, and mitigation techniques) to reduce the conservatism in modeling results.
- The need for wind speed limitations for radiological control should be carefully evaluated. While there is not an established standard for operations at specific wind speeds, employee perception may play a role in the decision. Also, the effectiveness of mitigation techniques (e.g., water misting/fogging) are adversely affected by elevated wind speed.

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RADIOLOGICAL CONTROLS
Yellow Brick Road

"Yellow-Brick-Road and skirting reduced time for surveying/releasing waste containers and shuttle truck."

Situation

Most of the waste from the 233-S Demolition Project was disposed in the Environmental Restoration Disposal Facility (ERDF), located approximately one mile to the east of the 233-S Facility. The ERDF was constructed to receive materials from a variety of Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) removal action projects that can be classified as low-level radioactive waste (not exceeding Class-C criteria). Waste materials destined for the ERDF are typically placed in large (approximately 22 ft x 8 ft x 6 ft) containers called ERDF cans, and then transported to the waste site after being loaded onto a shuttle trailer and truck.

Plastic tarp, locally known as the "Yellow Brick Road" creates a clean surface for a shuttle truck to transport ERDF can waste containers into and out of the 40-meter contamination area. This concept helped to significantly reduce the time spent performing radiological surveys.

During the 233-S demolition process, ERDF cans were required to be placed within the pre-established, 40-meter controlled contamination area (CA) boundary to facilitate loading the waste. Once the CA was full, the shuttle truck would need to also enter the CA to retrieve the ERDF cans. It was discovered early in the project that shuttle trucks would likely be significantly contaminated if moved into the CA/high contamination area (HCA). It was quickly realized that the initial decontamination efforts, as well as the radiological surveys required to release the shuttle truck/cans from the CA could be a major impact to the project schedule. These surveys involved both direct and smear contamination measurements over a substantial portion of the vehicle and container surface and were very time consuming.

To reduce the number of surveys required and minimize the time in extracting the ERDF cans from the CA, the following sequence of steps were taken:

- Prior to delivering an empty ERDF can, a pathway of plastic sheeting, the so-called "Yellow Brick Road," was installed across the CA. The "Yellow Brick Road" was posted as a Radiological Buffer Area (RBA) since it was free of contamination.
- The shuttle truck would back down the "Yellow Brick Road" to deliver an empty ERDF can.
- Once placed, a shroud of plastic sheeting was installed in a manner to protect the outside surfaces of the ERDF can from contamination. This sheeting was held in place via the use of magnets.

- After filling the ERDF can, the shroud would be carefully folded, keeping the contaminated side inward, and placed in the ERDF can on top of the demolition debris.
- The ERDF can was then surveyed to verify that it met the release limits. A survey plan was developed for this purpose that identified specific survey locations with the highest potential for contamination. This reduces the total of number of surveys performed.
- The "Yellow Brick Road" was surveyed to verify that it meets RBA status.
- The shuttle truck then backed down the "Yellow Brick Road" to retrieve the ERDF cans.
- Release surveys on the truck were limited to minimal verification surveys required for release from a RBA.

After removal from the demolition area, the ERDF cans were taken to a staging area to await transport to ERDF. Removal of the ERDF cans from this staging area also required release surveys.

Analysis

Additional time was required to set up the "Yellow Brick Road," but this impact was offset by avoiding decontamination efforts for the ERDF can and shuttle truck. Digital photos of the ERDF can were used to identify the locations where direct and smear measurements were to be taken. These photos facilitated performance of the exit surveys and helped ensure consistency.

Considerations for Future Projects

- Although the option was not available to the 233-S Project (due to the close proximity of neighboring buildings and structures), future demolition projects should evaluate the potential for establishing an RBA pathway that would extend from the CA to the waste container staging area. This configuration could eliminate one release-survey evolution.

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INDUSTRIAL SAFETY AND HEALTH
Equipment Noise and Communication Enhancement

"Some PPE for controlling exposure to high noise levels also impacts communication."

Situation

Noise generated by equipment during demolition of the 233-S Facility was often above the acceptable worker exposure limits of 85 decibels (dBA) Time Weighted Average (TWA). Such equipment included manlifts, concrete-coring drills, a large excavator with concrete shear, a fork-lift truck, and the concrete saw system. The highest noise levels were generated by the concrete saw, at 101dBA TWA. To control employee exposure to high noise levels, exposed employees were required to wear hearing protection in the form of foam ear plugs. The noise reduction rating of the ear plugs used by employees was adequate for reducing employee noise exposure to acceptable levels.

Custom-fitted hearing protection (with or without radio/cell phone interface capability) is commercially available; it provides a significant reduction in noise levels yet allows for effective communications. Fluor Hanford has purchased and is evaluating such equipment for selected use on future demolition projects.

When reducing the noise to acceptable levels, the foam ear plugs were not selective in the noise levels they reduced. Consequently, all employee noise exposure (including conversations) was reduced by the noise reduction rating assigned to the ear plugs. As a result of noise reduction, employees wearing ear plugs occasionally experienced difficulty at hearing and understanding verbal direction or conversation.

To address the problem of inadequate hearing/understanding of verbal direction or conversation when wearing ear plugs, discussions were held with a local hearing-protection supplier, and a decision was made to purchase custom-molded/fitted ear plugs for a selected number of employees (a total of four). These specialized ear plugs are designed to discriminate in the noise that they filter. While reducing/filtering out noise levels above unacceptable levels, the pre-molded ear plugs should not reduce noise levels at acceptable/conversational levels.

Analysis

Since the decision to procure the custom-fitted ear plugs was an initiative that began near the end of the 233-S Demolition Project (i.e., April 2004), the products have not been received at the time of this writing. Upon receipt of these ear plugs, however, the project's Industrial Safety staff (including the author of this Fact Sheet) will evaluate their effectiveness. The manufacturer of these custom units also offers a product that also allows for an industrial cell phone or radio adapter to the hearing protections to enhance the ability for remote communication.

Considerations for Future Projects

- When the pre-molded ear plugs arrive at the Hanford Site, the Industrial Safety representatives will test their ability to reduce high noise levels while not interfering with conversational noise. Follow-up information should be available from the contacts noted below.
- Demolition projects should evaluate other types of communication/hearing protection (e.g., as used by airplane/helicopter pilots). The ear muffs worn are used as both hearing protection and for listening to communications.
- Additional research and engineering fixes to employee exposure to high noise levels may be available from a project's Industrial Safety organization.

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INDUSTRIAL SAFETY AND HEALTH
Heat Stress

"Heat stress resulted in the need for strict monitoring and control of work/rest regimes."

Situation

During demolition of the 233-S Facility, elevated temperatures became an issue in regard to worker's heat stress. The summer's heat load on the building resulted in elevated temperatures inside the building, as the building's temporary exhaust ventilation and portable cooling systems were severely limited in their capability to ventilate and cool the building to acceptable levels. In addition to ventilation/cooling issues, the contamination levels and the wet conditions within the facility required that workers wear not only the standard of two pairs of protective clothing, but oftentimes required impermeable outer layers of clothing. As a result, the stay-times of workers in the building were severely limited, and additional workers were required to accommodate worker rotations. The heat stresses also contributed to an increased potential of personnel contaminations due to "sweat-through" of protective clothing.

Temporary structure (left center) was configured to allow D&D workers to stay out of direct sun and take periodic breaks during summer months to minimize heat stress.

Analysis

When FH assumed control of the 233-S Project in mid-2002, no significant work activity began until the fall/winter months. As the work progressed into the spring and summer months, the temperature inside of the building began to elevate, and heat stress to the workers became a significant issue. Three basic issues compounded the heat stress problem:

- The building ventilation was provided by a portable, skid-mounted, exhaust system and a trailer-mounted air conditioning system on the supply side. The exhaust system's flow rate far exceeded the air supply, so warm air was also pulled into the building.
- Water vapor impermeable, air impermeable, thermally insulating clothing, encapsulating suits, and multiple layers of clothing severely restrict heat removal.
- The building's concrete structure retained the solar heat load, causing the building temperatures to remain at elevated levels well into the evening hours.

When the project progressed into the spring and summer months and elevated temperatures began to manifest into heat stress issues, the stay-times of workers became severely limited and worker monitoring (e.g., body temperature, heart and respiration rates, body weight changes, etc.) became standard for all workers. While the most significant heat stress considerations were related to the work performed inside of the building, solar load resulted in heat stress issues to workers outside of the building.

The project had difficulty in procuring appropriate cooling systems. To maintain radiological contamination control, the cooling systems could not introduce more air into the building than the HEPA-filtered exhaust system could remove. The supply and exhaust system had to be balanced to maintain a negative pressure differential from contaminated areas to non- or lesser-contaminated areas thereby limiting the ventilation systems that could be used. The project eventually procured another cooling system that helped to achieve cooler conditions.

It is well known that water vapor impermeable, air impermeable, thermally insulating clothing, encapsulating suits and multiple layers of clothing severely restrict heat removal. With heat removal hindered by clothing, metabolic heat may produce life-threatening heat strain or stress even when ambient conditions are considered cool. While guidelines have been developed regarding layers of clothing, guidelines regarding layered clothing with an outer impermeable layer are limited. As such, the facility Industrial Hygienist (IH) had to develop guidelines. The guidelines discussed the appropriate methods for addressing heat stress issues while employees were completely dressed-out in impermeable clothing (i.e., impermeable coat and pants). The following procedures were established for working in conditions with the potential for heat stress when utilizing impermeable clothing at the 233-S Facility.

> The IH shall establish worksite and work location specific Wet Bulb Globe Thermometer (WBGT) values. The IH will establish a work/rest regimen by applying the following criteria:
>
> - Employees working in impermeable clothing will be allowed to work up to two (2) hours of work with one (1) hour of rest when the acclimatized, WBGT value is below 69.8°F. It should be noted that the one (1) hour of rest shall begin when employees have completed the "dress-down" process. The two-hour time period will begin after the employees have properly donned their PPE and are ready to enter and work in the area requiring the impermeable clothing. This two-hour work period may be increased if it is determined by the project IH that this may be done safely.
> - Employees working in impermeable clothing will be allowed to work up to one (1) hour of work with one (1) hour of rest when the acclimatized, WBGT value is above 69.8°F in the work area. It should be noted that the one (1) hour of rest will begin when employees have completed the "dress-down" process. The one-hour time period will begin after the employees have properly donned their personal protective equipment (PPE) and are ready to enter and work in the area requiring the impermeable clothing. This one hour work period may be increased if it is determined by the project IH that this may be done safely.

Industrial Hygiene Technicians utilized heart rate monitoring to assess sustained heart effort. The radial pulse was measured during a 30-second period prior to donning PPE and immediately following doffing PPE. Employees were instructed to measure their own pulse and relay the information to the IH Technician. If the heart rate exceeded 110 beats per minute at the end of a work-period, the next work cycle was shortened by one-third or the rest period lengthened by one-third. If the heart rate still exceeded 110 beats per minute at the end of the next work cycle, the following work cycle was shortened by another one-third or the rest period lengthened by another one-third.

The IH Technician monitored body weight at the beginning and end of each entry into the work area where impermeable clothing is required to determine if dehydration is occurring. Dehydration is defined as a 1.5 percent body weight loss over the entry period. Weight losses above this value indicated a need for further acclimatization or more frequent fluid replacement and evaluation of the employees' fitness for additional work.

The IH ensured that water/fluids were provided to workers as needed to prevent dehydration. The IH and IH Technician also encouraged workers to consume adequate quantities of water. In general, the recommended intake was eight ounces (one cup) of cool water every 15-20 minutes. Frequency of urination is one of the best indicators of adequate hydration. The IH or IH Technician may monitor the affected worker's frequency of urination and use this as a guide for gauging adequate hydration. The project IH had authority to impose mandatory consumption of fluids by the affected workers to ensure adequate hydration.

Considerations for Future Projects

- Heat stress issues are difficult to foresee. Even in cooler climates, heat stress should be considered as a potential issue, especially in those cases in which employees must wear layered clothing and/or impermeable clothing that prevents metabolic heat from escaping from the body.
- Projects should anticipate heat stress issues well before entering the spring and summer months. The best mechanism is to anticipate these issues and procure cooling systems to control temperatures to an acceptable level so as to mitigate the temperatures without the need for heat stress monitoring and work/rest regimes. Projects should utilize an engineering professional familiar with ventilation balancing and cooling capacities.
- Projects should consider purchase of personal cooling systems. However, the worker acceptance of these systems can become an issue. Purchase or loan of several varieties of cooling systems and trial by the workers may increase worker acceptance.
- Requirements for heat-stress monitoring and appropriate work-rest regimes should be defined early and understood by all employees. Additionally, all workers must be trained in heat stress issues and the means for detecting heat stress. Monitoring of heat stress by trained individuals is essential.

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INDUSTRIAL SAFETY AND HEALTH
Ergonomic Issues

"Handling of plastic tarps/sheeting in windy conditions created potential for ergonomic injury."

Situation

Aside from the standard ergonomic risks associated with laborious work tasks (i.e., lifting, pushing, pulling and twisting), demolition activities associated with the 233-S Facility gave rise to additional hazards. This project required the use of a wide variety of tarpaulins and plastic coverings designed for heating structures and storage tents. Various types of plastic materials were also used for radiological controls and to support the wrapping/shipping of demolition waste. The common factor associated with any of the tarpaulins and plastic coverings used for these demolition activities was the large surface area and height of the object being covered. When combined with prevalent, high winds at the Hanford Site, the result was the potential for serious ergonomic injury to employees.

D&D workers "negotiating" large plastic sheeting in high (but less than 12 mph) wind conditions. The sheeting was used to wrap concrete blocks removed from the 233-S process hood via saw cutting.

The 233-S Facility had a standing rule that demolition and waste loading activities would cease if the average wind speed was measured at 12 miles per hour (mph) or greater; it should be noted that this was a radiological control. Even at wind speeds that were much lower than 12 mph, the handling of large sheets of materials would present significant challenges. Therefore, conditions had to be assessed on a case-by-case basis to limit the exposure to employees working with the high-surface-area materials. In addition, steps were taken to secure tarpaulins or plastics used for radiological and wrapping/shipping waste. For example, chains were used to cover the perimeter of a plastic "road" placed upon the ground to minimize contamination to heavy equipment. Likewise, magnets and bungee cords were used to secure plastic liners in the metal waste containers, and steps were provided for those workers needing assistance when covering high objects.

Analysis

Constant monitoring of weather conditions proved to be effective in controlling potential ergonomic injuries associated with working with tarpaulins and plastic in windy conditions. On a case-by-case basis, the project evaluated the ergonomics associated with a specific task and made specific decisions to stop the work based upon wind conditions and risk of personnel injury. In addition, the steps taken to secure tarpaulins or plastics used for radiological and wrapping/shipping waste were effective. Employees were adequately trained in proper body mechanics and ergonomics which also helped to reduce the potential for ergonomic injury.

Considerations for Future Projects

- Changing weather conditions can present unique challenges to ergonomics. Demolition projects should be prepared to continuously re-evaluate the planned and the ongoing activities in terms of how the weather affects the work.
- Large-surface area plastics and tarpaulins may pose significant ergonomic risk to employees working in windy conditions. Steps should be taken to limit this type of work under such conditions.
- Some workers may require steps or ladders to cover high objects.

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INDUSTRIAL SAFETY AND HEALTH
Portable Heaters

"Portable heater needs and use should be reviewed with all workers prior to cold weather."

Situation

Demolition activities associated with the 233-S Facility took place during unseasonably cold and inclement weather. During this period, portable heaters of various types (e.g., electric, kerosene and diesel) were used throughout the project. The need for additional heaters increased as the winter conditions of 2003/2004 became worse than expected. Portable heaters were used to protect equipment that was vulnerable to freezing conditions (e.g., portable eye wash stations, water pumps, water hoses, and other equipment associated with the concrete saw cutting system). Portable heaters were also used to provide a temperature controlled environment for assembling and storing power air purifying respirators (PAPRs). Tent-like structures also housed portable heaters to mitigate cold-related stress and to enhance comfort for field workers.

Portable electric heater (right) used on 233-S project to maintain above-freezing conditions in a temporary enclosure; portable eye-wash station on left. To avoid potential personal injury and equipment damage, portable heater deployment must include a review of the applicable safety precautions and limitations associated with each type of heater.

Analysis

Portable heaters provided a cost-effective and feasible solution for the myriad of challenges associated with operating in the cold and inclement weather conditions. However, with the prevalent use of tarpaulins and plastic coverings for heating structures, extra care had to be taken to keep these combustible materials at a safe distance from any open heater.

A review of the applicable safety precautions and limitations with project personnel was paramount in the prevention of fire, personal injury and equipment damage. Employees were briefed on the applicable safety precautions and limitations of portable heaters at various plan-of-the-day and safety meetings. Generally, a minimum distance of at least 3 feet from any combustible materials was observed on the project site. In addition, kerosene and diesel-fueled portable heaters were not allowed to be used inside of tents or other heating structures due to concerns associated with the buildup of carbon monoxide.

Considerations for Future Projects

- Portable heaters can be extremely useful for providing temporary heating on job sites, particularly when the location and activities performed on the site make other types of heaters impractical.
- Care should be taken to ensure the proper type of portable heater is utilized for each situation (e.g., kerosene and diesel fueled portable heaters should not be used in enclosed areas).
- Portable heater use must include a review of the applicable safety precautions and limitations associated with each specific device. A refresher briefing on this topic should be provided to all project personnel prior to the cold weather season, and on an on-going basis during winter months.
- Portable heaters should meet all National Electric Code (NEC) requirements and display a label/listing certifying inspection by a nationally-recognized testing laboratory (e.g., Underwriter's Laboratory or UL).
- Portable heater use during high wind conditions can present additional potential for fire hazard.

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WASTE MANAGEMENT
Radiological Characterization of Building Structure

"Radiological characterization methods need to match field conditions."

Situation

When the 233-S Facility was transferred to Fluor Hanford in 2002, most of the facility's highly-contaminated equipment had been removed. However, due to processing upsets that took place in the 1950s and 1960s, a significant amount of radioactive contamination remained on and within the building's interior wall, floor, and ceiling surfaces.

Several characterization methods were used to support the downgrade of the 233-S Facility's radiological hazard category, to support waste characterization, and minimize the volume of transuranic waste. The image above shows characterization measurement locations (typically on 1/2-meter square spacing) on the 233-S process hood walls and ceiling.

Subsequent to the removal of contaminated processing equipment (but prior to demolition), an updated inventory of the contamination remaining in the 233-S Facility was needed to support the revision of a documented safety analysis (DSA) (compliant with Subpart B of 10 CFR 830, *Nuclear Safety Management*), and to determine how much of the facility's structure would be classified as low-level waste (LLW) vs. transuranic (TRU) waste.

Nondestructive Assay (NDA) techniques were initially chosen for characterizing the facility. Per guidance from subcontracted NDA expertise, however, it was recognized that the selected NDA technique would be effective if the general area exposure rates within the 233-S Facility could be reduced to <5 millirems per hour (mR/hr). Unfortunately, this condition was not met for several areas of the 233-S Facility due to high level of surface contamination as well as some contaminated material/waste that still resided within the facility. Even though these conditions were less than ideal (i.e., 100 to 300 mR/hr), NDA measurements were obtained throughout the facility without removing waste, performing additional decontamination, or shielding of hot spots.

Analysis

Due to the high general-area exposure rates that remained in the 233-S process hood (and the recognized uncertainty that these exposure rates introduced into the data analysis), the total gram quantity of TRU constituents from the NDA measurements were acknowledged as "worst-case" conditions and overly conservative. While this conservative NDA assessment was still sufficient to support a downgrade from a Hazard Category 2 Nuclear Facility status to a Radiological Facility status, the assessment was not sufficient to support waste characterization. If the NDA assessment was used for waste characterization purposes, the entire process hood would have been designated as TRU waste.

The project subsequently developed and implemented a plan to reduce the uncertainty and conservatism that was inherent to the NDA assessment. The new approach required the removal of all waste and other accumulated/contaminated materials. Also, a 12-inch layer of grout was installed to shield the exposure from contamination on the process hood floor. A detailed sampling grid was then established over the entire facility's wall and ceiling surfaces. The grid spacing varied according to contamination level and distribution; closer spacing was used for areas of high contamination and potential areas of heterogeneous distribution. A lead-shielded, sodium-iodide detector was calibrated specifically for americium-241. The lead shielding created a directional detector which minimized interference from contamination on surfaces other than the one being measured. Exposure measurements were obtained at a distance of 30 centimeters from each grid center and converted to a gram quantity of TRU using an exposure to curie calculation method. The individual mass determinations were summed to provide a total TRU mass for each grid block and for the entire facility. This approach required an investment of several weeks to establish the survey grid and obtain the data, but proved to be very successful. Rather than designating the entire process hood (approximately 2,700 cubic feet) as TRU waste, this more detailed characterization approach determined the TRU waste volume to be about 500 cubic feet. However, based on subsequent discussions with DOE and EPA regarding volumetric-weighted-averaging of the concrete slabs, the final volume of TRU waste was reduced to less than 150 cubic feet.

Considerations for Future Projects

- NDA characterization can be much more cost effective than physical sampling and laboratory analyses. However, depending on the co-contaminants, high general-area exposure readings might interfere with data quality and introduce unacceptable levels of uncertainty. Overly conservative characterization data can have significant cost implications for waste handling and disposal.
- The "micro-R" sodium-iodide detector was very effective at locating TRU contamination areas within the 233-S process hood. These detectors were specifically calibrated for americium-241 (^{241}Am) and shielded with lead to eliminate interference from sources outside of each sampling area. The isotopic distribution ratio of ^{241}Am to plutonium (previously determined by physical sampling and laboratory analysis) was then used to determine the levels of TRU for each sampling area.
- Characterization on a small (1/2-meter square grid) sample spacing allowed for the ability to segregate TRU hot spots and minimize the actual volume of TRU waste.

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WASTE MANAGEMENT
Loading and Packaging of Concrete Rubble

"Waste handling required more time and resources than originally estimated."

Situation

The single-story and less-contaminated portions of the 233-S Facility were demolished by use of an excavator with a concrete shear attachment. After several hours of shearing, a front-end-loader was used to place the pile of concrete rubble into a large (6 ft x 6 ft x 20 ft), steel, roll-off/drag-on, open-top, tarp covered, waste container. These containers were transported to Hanford's Comprehensive Environmental, Response, Compensation, and Liability Act of 1980 (CERCLA) landfill, known as the Environmental Restoration Disposal Facility (ERDF). These waste transportation containers are locally called "ERDF boxes."

Loading and packaging of plutonium-contaminated concrete debris involved detailed handling processes. Plastic sheeting was extensively used to wrap/contain for contamination control purposes.

This apparently straight-forward process was more complex due to the limitations on site access/egress, and the detailed steps that were necessary to maintain contamination control.

Analysis

In general, the time and resources necessary to prepare, place, load, seal, secure, survey, remove, and stage an ERDF box for disposal were greater than originally anticipated. The restricted area (e.g., neighboring buildings, pipe trenches, and underground tanks) surrounding the 233-S Facility also created a number of logistical challenges for efficient access to and egress from the demolition zone. Even though a site plan was developed for the delivery/placement/removal of ERDF boxes as well as pathways for the excavator and front-end loader, the project site was still very constricted.

Radiological control aspects of the waste packaging process presented challenges in the areas of (1) providing clean access for shuttle truck to deliver/remove ERDF boxes, (2) preventing the outside of the container from becoming contaminated during loading, and (3) the time required to survey the truck and box for release to uncontrolled areas.

In order to allow for a clean shuttle truck to access approximately 50 ft into a contamination area, a 15-ft-wide pathway of plastic sheeting (locally called the "Yellow Brick Road") was positioned over the contaminated ground as a driving surface. Chains were used as easily moveable anchors for securing the plastic sheeting from wind movement. Steel plates (½-inch thick) were placed where the ERDF box was to be located; the ERDF boxes were then rolled-off a shuttle truck trailer and onto the plates. This access/egress system worked very well; plastic was able to be reused with minimal survey time and eventually discarded after being damaged by truck tires.

The ERDF box was protected from contamination by placing a "skirt" around the lower ¾ of the ERDF box. Tape was originally used to secure the skirt to the container, but was later replaced (per recommendations from the workers) by a series of magnets. The ERDF box waste packaging system utilized a plastic liner and "burrito bag" for the inside of the container. The burrito bag was draped over the outside of the box, and hung approximately halfway down the box (overlapping the skirt and providing complete coverage of the outside of the container). The closure process involved folding the liner and burrito bag into the box and sealing it. This approach worked very well; over 60 ERDF boxes were successfully removed from the contamination areas without a significant contamination event.

Even with the efficiency improvements noted above, the maximum number of boxes that could be placed, loaded, and removed from the contamination area during each shift was two (per loading location), with the average being one.

Considerations for Future Projects

- Adequate time for waste box handling should be included in duration planning. For this project, preparation of the ERDF box took approximately one hour and three workers. Closure of the ERDF box, loading on the shuttle truck and radiological release surveys took approximately two hours. Efficiencies were made by preparing the ERDF box prior to placement within the contamination area, reusing plastic, and establishing a second ERDF-box-loading station.
- If ample space is available near the demolition zone, multiple loading locations would allow for loading of containers to proceed while container closure activities occurred on others. Due to very limited access near the demolition zone, this project established a second box-loading station close to the first station; both were simultaneously loaded and closed. This upgrade effectively doubled the throughput, but required twice the personnel resources.
- The process for off-site shipment of the waste containers should be decoupled (i.e., geographically separate) from loading process. This approach worked very well for this project; additional containers were required to allow for lag storage, and there were no instances of project delay due to container shipment schedules.

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WASTE MANAGEMENT
Waste Packaging – Liquid Absorbent

"Polymer absorbent mitigated problems of free liquids in waste containers."

Situation

Free liquids were not permitted in the large roll-off containers that were used for transporting the 233-S Facility's demolition debris to Hanford Site's Environmental Restoration Disposal Facility (ERDF). This restriction represented a challenge for the 233-S Facility Demolition Project due to the water mists that were continuously applied to the zone of concrete shearing for contamination control purposes. For the same purposes, water mists were periodically applied to demolition debris piles.

To help ensure that liquids would not escape from the waste containers, the project's waste management staff conceived an idea for using a highly-efficient polymer absorbent called WaterWorks Crystals®. The concept involved placing a prescribed amount of the WaterWorks® product into long, tubular "socks" and installing them near the seals of the waste container's rear door.

Custom-made "socks" containing a superabsorbing polymer material were placed near the rear seal on waste containers destined for Hanford Site's ERDF landfill. The absorbing socks effectively ensured that free liquids would be absorbed and not leak from the containers.

Analysis

A small business contract was established for water-absorbing socks (approximately 6 in. diameter x 8 ft long) to be fabricated with a premeasured amount of the WaterWorks Crystals®. The socks were sewn from scrap nylon materials acquired from local second-hand stores and delivered to the project. The WaterWorks Crystals® product is a cross-linked polymer that is claimed to be capable of absorbing up to 400 times its weight in water. The product worked exceptionally well as it eliminated further instances of leaking waste containers. This product has been effectively used and accepted by the ERDF landfill.

Considerations for Future Projects

- Upfront planning for liquid accumulation/removal scenarios prior to waste disposal activities might mitigate delays in waste shipments.
- Pre-approvals for use of particular absorbents should be obtained from the waste disposal support organizations.
- Polymer absorbents can be effective for controlling and removing free liquids in waste containers.

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WASTE MANAGEMENT
Bulk Packaging Systems

"Innovative, bulk-packaging systems can be utilized to safety ship highly contaminated waste."

Situation

The initial waste disposal plans for the 233-S Facility Demolition Project included the use of the following standard packaging and disposal methods:

- Step-off pad and other soft wastes generated during the project were destined for 4 feet (ft) x 4 ft x 8 ft metal waste boxes that would be used one time, would cost about $3000 per container, and would hold 10-20 bags of the soft waste.
- Demolition debris classified as Low Specific Activity II category (LSA-II) would be placed in 12 roll-off containers (qualified per 49 CFR 173.411, *Industrial Packaging*), each costing about $25,000.
- Saw-cut concrete slabs from the 233-S process hood would be cut small enough to fit into a roll-off container.

Large (22 ft x 8 ft x 6 ft), reusable, roll-off waste boxes with heavy-duty polyethylene liners were used for packaging and shipment of non-transuranic waste from the 233-S Facility.

Several initiatives were subsequently pursued to help minimize waste packaging, transportation and disposal costs. These initiatives involved the use of flat-bed trailers, reusable roll-off containers (approximately 22 ft x 8 ft x 6 ft), and Industrial Package (IP)-I qualified liner systems in order to meet IP-II shipping requirements.

Analysis

Instead of using the 4 ft x 4 ft x 8 ft metal waste boxes for transportation and disposal of soft waste, reusable roll-off containers were used. These larger containers held 75 to 100 bags of soft waste. Cost for disposal of this waste at the Environmental Restoration Disposal Facility (ERDF) site was only $470 per container load; this represented significant cost avoidances compared to the metal waste boxes costing $3000 each.

Instead of spending up to $300,000 on IP-II qualified waste shipping containers as noted in the second bullet above, approvals were obtained on the use of a custom-designed, container/liner system for the shipment and disposal of all non-transuranic (TRU) waste. This heavy-duty intermodal liner with protective inner liner system was locally called the "burrito bag." This packaging system was initiated by placing the burrito bag within the drag-on container (with ends draped over the sides of the waste container). Then an inner liner was placed on the open burrito bag, and 12-18 inches of soil was placed onto the inner liner. After filling the container with demolition debris (e.g., concrete rubble), additional soil was placed over the top of the debris, and a heat gun was used to seal the inner liner. Rope-lacing on the burrito bag was then cinched and tied to finalize closure of the liner package. Use of this system received joint approvals from the ERDF site management, the U.S. Department of Energy, Richland Operations Office (RL), and the U.S. Environmental Protection Agency (EPA).

In order to minimize the exposure of hazards to workers and the possibility of contamination spread while cutting the concrete roof and walls of the 233-S process hood, discussions were held with representatives from the ERDF, DOE, and EPA regarding waste transportation options; agreements were reached that allowed for the use of flatbed trailers for hauling concrete slabs. The use of flatbed trailers (in addition to roll-off containers) allowed for larger slabs of concrete to be cut and removed from the process hood. The ability to cut and transport larger concrete slabs also reduced the total number/length of cuts that were necessary to dismantle the process hood structure.

Considerations for Future Projects

- Use of reusable, bulk shipping systems will likely result in cost, manpower, and project schedule savings.
- With adequate contamination controls in place, smearable alpha contamination levels in the millions of disintegrations/minute/100 cm^2 can be safely shipped using bulk containers.

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WASTE MANAGEMENT
Water Accumulation and Collection

"Demolition water accumulation/collection was much less significant than anticipated."

Situation

Water (with and without additives) was used throughout the demolition project to suppress airborne dust, apply fixatives, and to lubricate, cool, and decontaminate equipment. During the concrete shearing process, two MARTIN® FOG CANNONs™, were used to direct a 14-gallon-per-minute misting of water toward the zone of shearing. A specialized series of water spray nozzles was also installed near the end of the excavator arm to apply a fine mist immediately near the throat of the concrete-shearing jaws; this water was very effective for controlling dust migration, and each unit applied approximately eight gallons per minute. Additionally, two-inch-diameter hoses were used to manually apply water and fixatives to keep debris piles wetted. The diamond-blade wall saws required 3 to 6 gallons per minute to support blade cooling, lubrication, and clearing of sediment from the kerf. During the project planning and preparation phases, peak water applications were estimated at approximately 35 gallons per minute, or 2,100 gallons per hour during the shearing phase of the project.

Contrary to original expectations, water used for demolition dust suppression, fixative applications, equipment cooling, and decontamination did not accumulate to levels of significance within the contamination area.

It was known that several feet of gravel and several layers of asphalt were installed around the 233-S Facility since the 1960s in order to cover up sub-surface contamination. Without performing significant excavation or bore sampling, it was difficult to estimate the underlying "water-holding capacity" of the surrounding sub-surface gravel. Given these unknowns, the project planned for worst-case conditions by ensuring that a sufficient number of sump pumps, water collection troughs, and holding tanks would be available for use if needed.

Analysis

While the estimated water application rates were accurate, the variables associated with actual sub-surface soil/gravel and asphalt conditions, actual durations of demolition on a daily basis, and weather (including relative humidity, wind conditions, and ambient air temperature, etc.) proved to be favorable with regards to water accumulation and collection needs. Due to unseasonably cold weather conditions, a mid-course decision was made to reduce field operations from two shifts per day to a single shift per day. This change also minimized water accumulation and runoff concerns. Overall, ponding of demolition water was very minimal throughout the entire demolition project.

Considerations for Future Projects

- The semi-arid environment at the Hanford Site can be viewed as generally favorable with respect to rates of evaporation and water-holding capacity of the native soils.
- Similar demolition projects in non-arid environments (e.g., DOE's Savannah River and Oak Ridge sites) may experience significantly different results.
- Sub-surface soil conditions can favorably or unfavorably influence the moisture holding capacity of soils near a given demolition site, and the migration of waters to regions outside of the designated surface contamination area.
- Irrigation hardware and agricultural equipment suppliers (especially in arid regions) typically maintain an inventory of the types of equipment needed to capture and collect unplanned volumes of waste water. Near the Hanford Site, this type of equipment can be procured on a quick-turnaround basis.

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